MARINE FIELD METHODS
SPRING 2009

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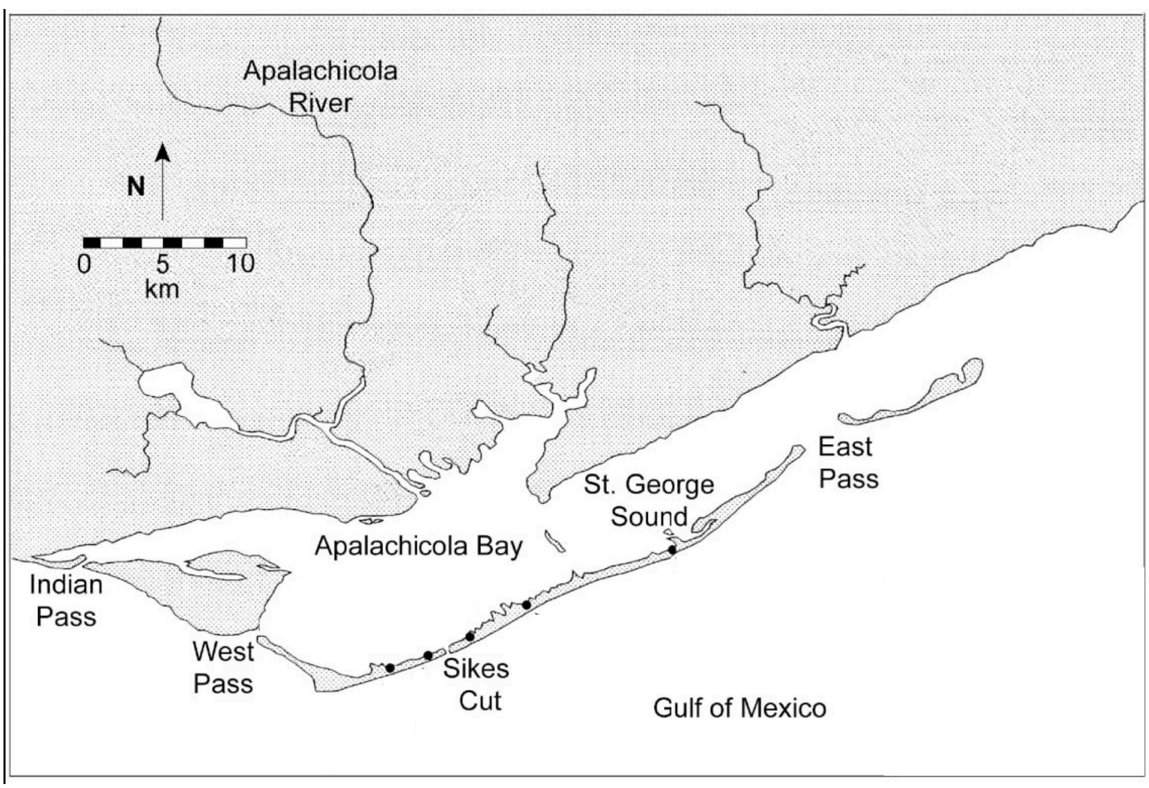
BACKGROUND

Apalachicola Bay is a bar built estuary in North Florida surrounded by several barrier islands. The Bay is highly productive and strongly influenced by the Apalachicola River. The River provides 90 percent of the freshwater input to the estuary. Along with this freshwater, nutrients from the drainage basin also enter the estuary. The freshwater from the River is mixed with the salt water of the Gulf of Mexico. This salt water enters primarily from East Pass into St. George Sound, but can shift due to wind and tides from time to time. The mixed water exits the estuary through West Pass and Indian Pass. During our study, heavy rains and a strong west wind played an important role in the results of our data. (Dulaiova 2008)

MOTIVATION

The motivation behind the study was simple. The first goal was for students to gain experience using scientific instruments aboard a marine research vessel. The second goal and focus of the experiments was to track the river plume as it exited the Apalachicola Bay. The original cruise plan was altered due to weather and time constraints.

GEOGRAPHY



CRUISE PLAN

The Research Vessel BELLOWS is operated by the Florida Institute of Oceanography on behalf of the State of Florida and the State University System. It is designated and certified as an Oceanographic Research Vessel by the US Coast Guard. The normal operational areas for the BELLOWS are the Gulf of Mexico, SE Atlantic, Bahamas and the northern Caribbean Sea. Research disciplines supported are Biological, Physical, Seismic, Geological, Environmental and Weather. Numerous universities and agencies, both state and federal are users of the BELLOWS.

Cruise Plan Leg 1

On Tuesday, April 7, 2009 at 0700, the crew of students and instructors boarded the RV Bellows for the first day of the study. The ship headed Northeast toward Dog Island then returned to Carrabelle to dock for the night. The ship departed Carrabelle and headed for K Tower. Demonstration of the instruments and operations was conducted at 12 stations during the cruise. Four (4) core samples were taken at Station 000. No drifters were deployed.

We left the Moorings on Thursday morning around 8:00 am. We went directly to East Pass and set out drifters for several hours. High tide was at 2.29 pm. We pulled the drifters TIME and went to CTD stations. We started out with station 13 and went to 22 taking measurements with the handheld YSI and the rosette CTD's.

Left anchorage Friday morning approximately 7:30 a.m. and went to East Pass again. We took salinity readings on the handheld YSI form several stations beginning on the outside of the pass and working our way back into the bay (south to north). We then deployed the rosette CTD's again for stations 23 through 28. These stations were east to west. Around noon, we deployed both drifters and followed them until about 4:30 pm.

On Thursday, we noticed a general trend of more saline or ocean water in the bottom layers and fresher water near the surface. In the east part of the bay, the water at the surface was very fresh, measuring 1.9 ppt at the last station. Temperature was 18 to 19 degrees.

On Friday, the water in East Pass was more mixed probably due to the tide changes overnight and increased seas. There was a indication of more saline water near the bottom (30 ppt) and fresher near the surface (11.1 ppt). These readings represent the highest and lowest readings taken from the handheld YSI.

STATIONS

STATION LIST						
STATION	**DATE**	**TIME (EST)**	**LAT**	**LON**	**DEPTH**	**OBSERVATIONS**
000	04/08/09	0920	29 48.357	84 40.390	15	4 cores taken
001A	04/08/09	1207	29 40.171	84 22.111	59	bad values on the CTD
001	04/08/09	1238	29 40.419	84 21.978	58	K Tower
002	04/08/09	1304	29 41.110	84 22.655	60	
003	04/08/09	1335	29 41.942	84 23.637	52	
004	04/08/09	1350	29 42.787	84 24.357	42	KT2_4
005	04/08/09	1406	29 43.836	84 25.238	41	
006	04/08/09	1423	29 44.721	84 25.892	35	
007	04/08/09	1440	29 45.756	84 26.712	32	
008	04/08/09	1456	29 46.727	84 27.600	34	
009	04/08/09	1512	29 47.772	84 28.342	31	Station B
010	04/08/09	1545	29 48.037	84 31.023	20	KT2_2. Redone (ground)
011	04/08/09	1603	29 48.738	84 29.300	18	
012	04/08/09	1732	29 51.761	84 31.547	12	Station A
013	04/09/09	1602	29 53.200	84 26.955	16	
014	04/09/09	1632	29 52.171	84 29.238	14	
015	04/09/09	1703	29 51.669	84 31.515	14	Station A
016	04/09/09	1731	29 50.954	84.33.364	16	
017	04/09/09	1801	29 50.399	84 39.344	20	
018	04/09/09	1828	29 49.278	84 36.565	14	
019	04/09/09	1849	29 48.157	84 37.389	15	
020	04/09/09	1914	29 47.892	84 39.384	15	
021	04/09/09	1943	29 47.115	84 41.465	15	
022	04/09/09	2016	29 46.244	84 43.274	12	

STATION LIST						
STATION	**DATE**	**TIME (EST)**	**LAT**	**LON**	**DEPTH**	**OBSERVATIONS**
023	04/10/09	1050	29 46.150	84 41.972	16	
024	04/10/09	1107	29 46.404	84 41.747	14	
025	04/10/09	1116	29 46.479	84 41.393	18	
026	04/10/09	1124	29 46.677	84 41.044	18	repeated profiles
027	04/10/09	1146	29 46.880	84 40.804	18	
028	04/10/09	1145	29 46.993	84 40.613	15	

nb: the depth is measured from the echo sounder, which is located 4.5 feet under the waterline.

OBSERVATIONS

Drifters

*note: St. George Sound has been referred to as SGS throughout the description.

Drifter Construction
Two different drifter prototypes are tested. While both drifter designs are based on the Davis / CODE drifter design, certain modifications are made in order to stay within low-cost budget constraints. Each drifter includes a spherical radar reflector (roughly 1.5ft in diameter), a GPS data logger, and a frame constructed from 1.25" PVC piping. Drifter A is 7ft tall with 4 wings, each 2ft wide x 3ft tall (Fig. 1). Drifter B is 8 ft tall with 4 wings, each 1.5 ft wide x 4ft tall (Fig. ???). Canvas is added to cover each wing for increased drag, and a one-gallon air-filled jug is attached to the outermost corner of each wing using a 10-inch section of rope. When in the water, the frame of the drifter is suspended from the floatation (jugs) by these 10-inch sections of rope. This is intended to allow the surface floatation to move independent of the drifter frame, thereby reducing the wind and surface drag. Each drifter also has a central post that extends roughly 3.5ft above the water surface. The GPS data logger and radar reflector are mounted to this post, allowing constant monitoring of location from the ship Twelve metal rebar rods are placed in the PVC piping at bottom of drifter B's frame to enhance vertical stability. Tension on the floats at the four corners of the wings also provides stability against severe listing. Drifter construction is intended to withstand a minimum of one full tidal cycle in the water.

Drifter Release Methodology
See cruise plan section

Observations: Cast 1
Two separate drifter release casts are made. The first cast occurred on 9 April 2009 around 10:30 AM. When both drifters A and B were released, they were approximately 125m (~411 ft) apart in East pass between St. George Island and Dog Island (figure 2). The large distance between drifter release positions occurred due to technical delays in deployment time. Both drifters initially moved to the west-northwest into SGS. It was along this W-NW path that the drifters reached their largest speeds, near 35 cm/s. After 45 minutes, each drifter changed course to follow a mostly along-isobath track toward the northeast. Along this northeasterly track, the drifters gradually slowed to around 10 cm/s, until they were retrieved from within the main channel. Throughout the course of their tracks, both drifters remained in water depths between 5 and 8 meters, avoiding shallower waters. By remaining in deeper waters of the channel, where the tidal flow should be stronger, the drifters followed a path of least resistance. Drifter A followed a more westerly track initially, and exhibited a more dramatic 90-degree turn once within the sound. Drifter B's track followed a more gradual turn to the northwest, although it experienced a slightly larger maximum velocity.

The maximum speeds of each drifter occurred less than 5 minutes apart, with Drifter B reaching its maximum near 10:46am and Drifter A reaching its maximum near 10:51am. Meridional and zonal drifter velocities (figure 4a.) also reflect the nature of their trajectories. Initially both drifters have negative U velocities, indicative of westward flow. The flow direction reverses as drifters begin to follow an eastward path around 11:10am. It is also at this time that the greatest accelerations are observed. Positive U velocities indicate eastward flow for the remainder of the time the drifters are in the water. Likewise, the timeseries of V velocities reveals coherent northward flow during the deployment, tapering to zero (or slightly negative) near the end of the tracks.

Observations: Cast 2
The second cast occurred on 10 April 2009 around 12:15pm. Drifters A and B were released approximately 5.5m (~18ft) apart very close to the previous release position, between St. George Island and Dog Island. Release times in cast 2 differed by less than 5 minutes. For the first 1.5 hrs, each drifter moved slowly away from SGS toward the Gulf of Mexico (within East pass), although the maximum outward distance was only 197 m (~647 ft) from the release location. After this maximum outward distance was reached, each drifter began to travel back into SGS. Once drifters were inland of St. George Island, they again turned and followed an along-shore route, although this time toward the east-southeast. The highest velocities for each drifter were again achieved during the along-shore transect within SGS. While Drifter A exhibited the greatest maximum speed (43.56 cm/s), two separate peaks on the order of 30 cm/s were observed in the total speed of Drifter B (figure 3b.). Upon entering SGS, the drifters consistently held a drifting speed of at least 20 cm/s.

Once again, the drifter U and V velocities reveal the directional components of the flow, with predominately westward flow for the duration of cast 2. Meridional velocities indicate northward flow through East Pass, which gradually turns southward as the drifters enter the main portion of the sound. It is should be noted that the magnitude of the acceleration for Drifter A is 20-25% larger than that of Drifter B for both casts on consecutive days. Given the limited amount of observational data, it is hard to speculate on the significance of this result. Nonetheless, this could possibly be explained by the fact that Drifter A was constructed with broader and shallower sails (wings) as compared to Drifter B, thus making it more sensitive to changes in the speed and direction of any shallow surface currents. The deeper sails on Drifter B make it subject to greater shear in the vertical, which could potentially limit its response to shallow surface currents.

Observations: Dispersion
Absolute drifter dispersion (cm^2/s) versus time was computed using the following relation:

$$K_{abs} \sim \frac{d}{dt}\left(\langle x - x_o \rangle^2\right)$$

where x_o is the initial drifter position. This was done for casts 1 and 2 separately (figure 6a.) and then averaged together to find the total drifter dispersion over time (figure 6b.).

The total absolute drifter dispersion has a sharp increase initially and then flattens out. This is indicative of random motions that quickly separate the drifters from their initial positions, but tapers off over time. Later in the timeseries, there is a more steadily sloping region that begins around 2.3 hours after release. If we consider the slope of this region to be representative of the dispersion coefficient operating over our timescale, we get a value of 6.57 x 10^5 cm^2/s. In a 1997 study by Wanninkhof et al. over the west Florida shelf, they observed horizontal diffusion coefficients of 1.70 x 10^5 cm^2/s and 24.08 x 10^5 cm^2/s over the course of 3 and 7 days respectively. Our number seems to be in rough agreement with those found by Wanninkhof et al. for the dispersion operating over a similar region for a relatively short time scale. A longer dispersion time would increase the window for the influence of larger scale features such as storms and eddies. For example, drifter dispersion of longer than several weeks is dominated by frontal events and tropical storm forcing in the eastern Gulf of Mexico (Ohlmann and Niiler, 2005). Ohlmann and Niiler found an eddy diffusion coefficient of between 3.1 x 10^7 cm^2/s and 6.5 x 10^7 cm^2/s for the nearly year long SCULP-II study. It would be interesting to see what out drifters would have done if deployed for a longer time period. Unfortunately this was not possible due to logistical concerns over the difficulty of deployment and recovery in relatively rough conditions.

Relative drifter dispersion over time (figure 7b.) was also computed for cast 1 (top panel) and cast 2 (bottom panel) using the following relation:

$$K_{rel} \sim \frac{d}{dt}\left(\langle x_2 - x_1 \rangle^2\right)$$

Where x_1 and x_2 are the positions of drifters 1 and 2 respectively. It is interesting to note that the maximum dispersion observed for cast 2 was 1.5-2 times larger than the maximum for cast 1, while the average dispersion was comparable for both days. Independent meridional and zonal dispersion values were calculated. It should also be noted that the meridional dispersion is slightly higher, on average, than the zonal dispersion for both casts. There seems to be no clear pattern in the magnitude of the flow velocities that would explain this observation. However, it may be possible that the meridional tidal flow through the pass may be slightly more dispersive than the zonal flow component. In addition, the relative dispersion observed at the end of the drifter trajectories (as the drifter paths came closer together) was substantially less than the values observed earlier in the timeseries.

Conclusions

The drifter design and construction was reasonably successful. The drifters were deployed on consecutive days for over four hours at a time and recovered without any structural damage. The sail and floatation design seemed to provide a reasonable estimate of the surface current. However, given the small amount of data collected, it is hard to distinguish between the relative contribution of tidal, wind, and wave forcing. The GPS data logger was able to produce a continuous record of drifter position every second, with no apparent interference from the radar reflector or wave activity. During the relatively calm seas of cast 1, drifter position was successfully monitored using the ship's radar.

Conversely, seas of 2-4ft present during cast 2 prevented any consistent radar readings, and it was necessary to visually track the drifters from the ship. In future studies, the radar reflector should be mounted higher above the water surface so a better line-of-site can be maintained.

Drifter trajectories seem to correspond with tidal forecasts fairly well for cast 1. However, trajectories for cast 2 appear slightly askew from tidal forecasts. The initial outward movement of the drifters should correspond with the outgoing tide at this time. However, the provided tidal forecast predicts an incoming tide for the entire period of drifter advection. This inconsistency is likely due to a poor tidal model being used for forecasting tides.

To analyze the effect of the winds on the surface drifter circulation, wind speed and direction data from two different observation stations near Apalachicola Bay are analyzed. The first station is National Estuarine Research Reserve System Station APXF1 is located north of Eastpoint, FL. The second station is Tyndall Air Force Base Tower C (N4) located about 20 miles south of St. George Island.

Timeseries of the surface winds reveal that the wind was about 0.75 m/s from the south at the time each drifter was released during cast 1 (figure 8). These winds slowly died over the period that the drifters were in the water on 9 April. Winds then weakened for the next day, until they increased to about 0.25 m/s from the northwest around 2:30pm. This change in wind speed and direction corresponds with the change in direction of the drifters' tracks between cast 1 and cast 2. The greatest difference between cast 1 and cast 2 is this change in direction that the drifters take upon entering the waters of SGS (figure 2). The weakening of the winds in the afternoon of April 9 corresponds quite well with the time of weakening drifter velocities.

During cast 2, winds from the northwest do not explain the westerly drifter tracks. However, these northwesterly winds are weak in comparison to winds the previous day. Thus, it could be assumed that the wind forcing on the surface currents was minimal during this second day. The question remains, however, why the drifters traveled to the west instead of to the east. If one considers the buoyancy gradients observed from the large influx of fresh water into the St. George Sound, it could be assumed that the buoyancy driven flow coupled with an incoming tide and decreased wind forcing led to westward movement of the drifters during cast 2.

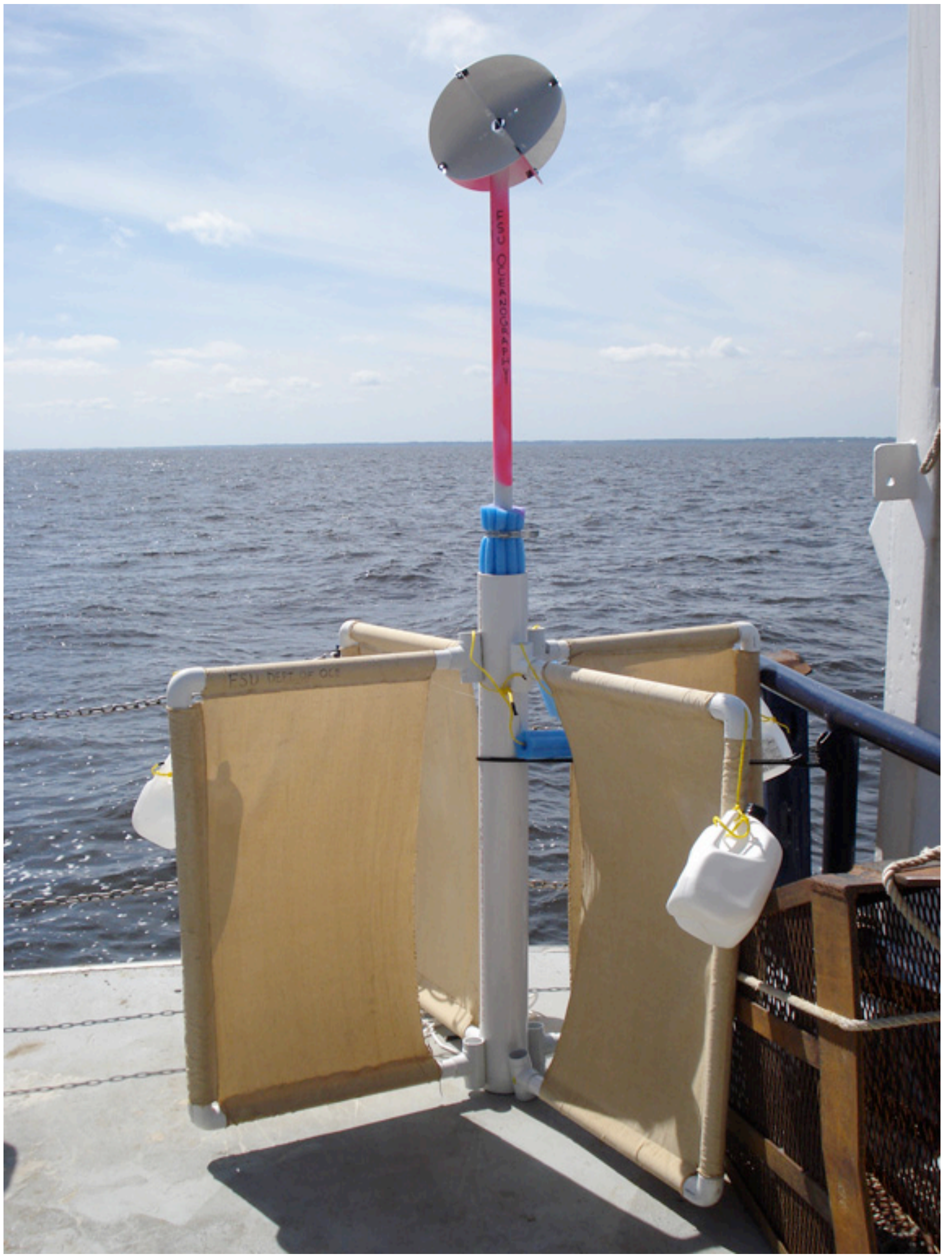


Figure 1. Drifter A onboard the *R/V Bellows*.

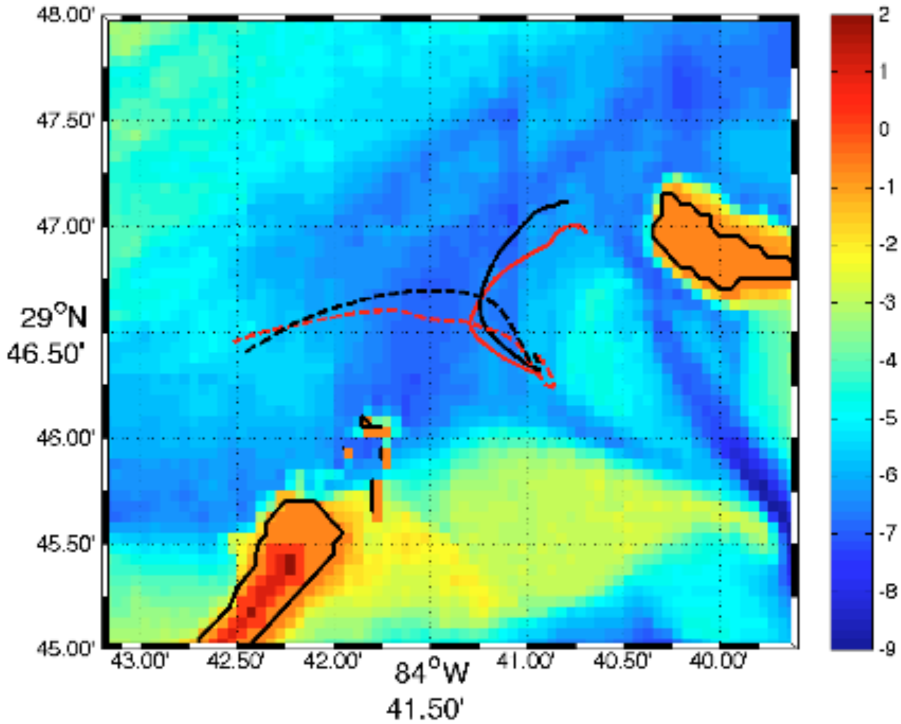
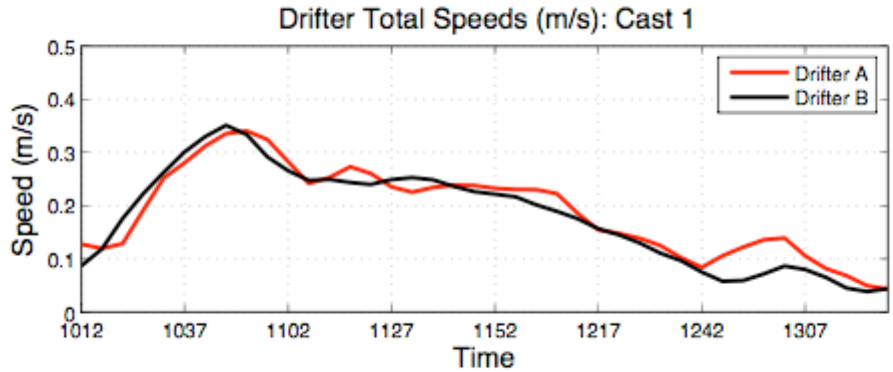


Figure 2. Tracks showing drifter position with time as they move from the entrance of East Pass to inside St. George Sound during the incoming tide. Drifter tracks for cast 1 are represented by the solid lines, while cast 2 tracks are dashed lines. For both days, Drifter A is shown in red and Drifter B in black. Bathymetry contours indicate depth (m), where positive values are elevations on land. The coastline is outlined in black.

(a).



(b).

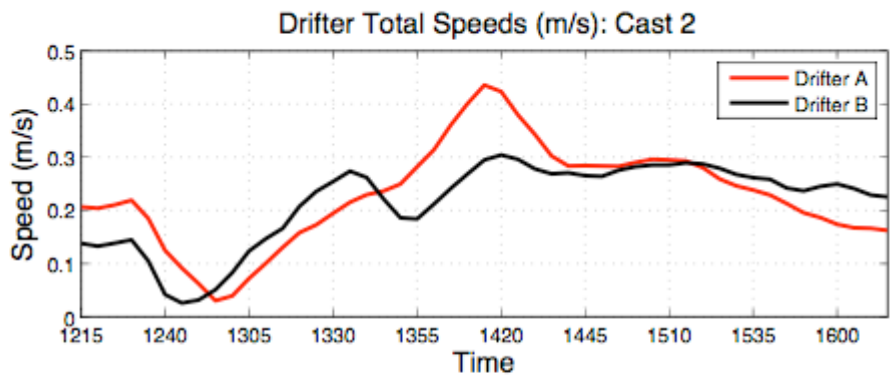
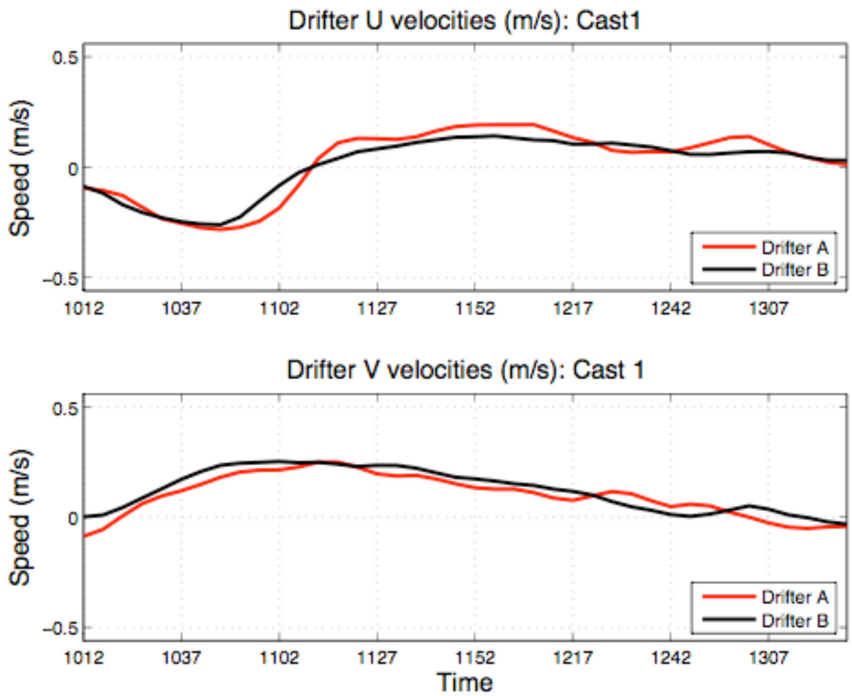


Figure 3. Timeseries of combined drifter speed for Cast 1 (a) and Cast 2 (b) computed from 5 minute averaged drifter velocities. Maximum speeds for the first day were observed shortly after drifter deployment. However, on the second day neither drifter reached its maximum speed until the middle of the timeseries.

(a).



(b).

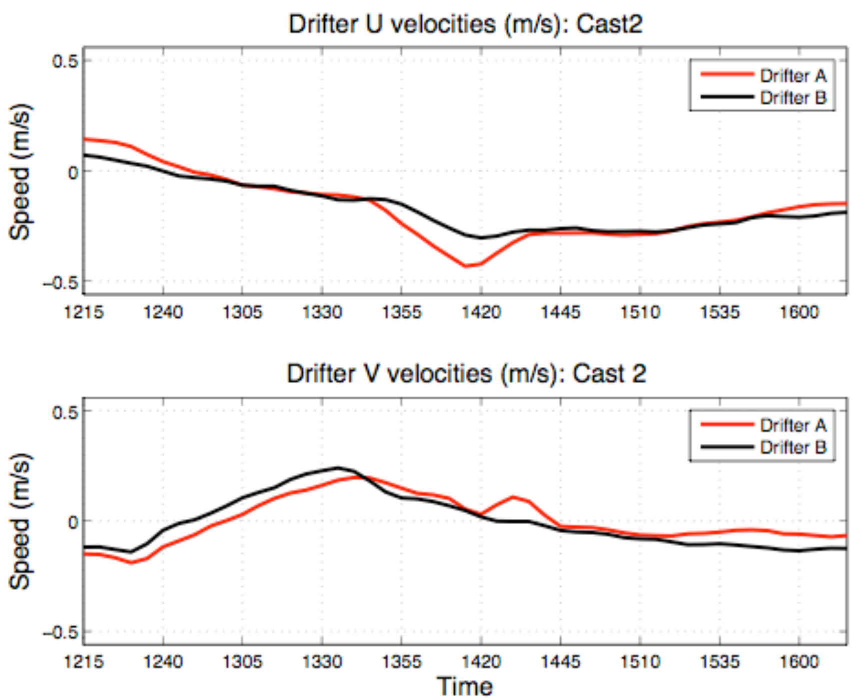
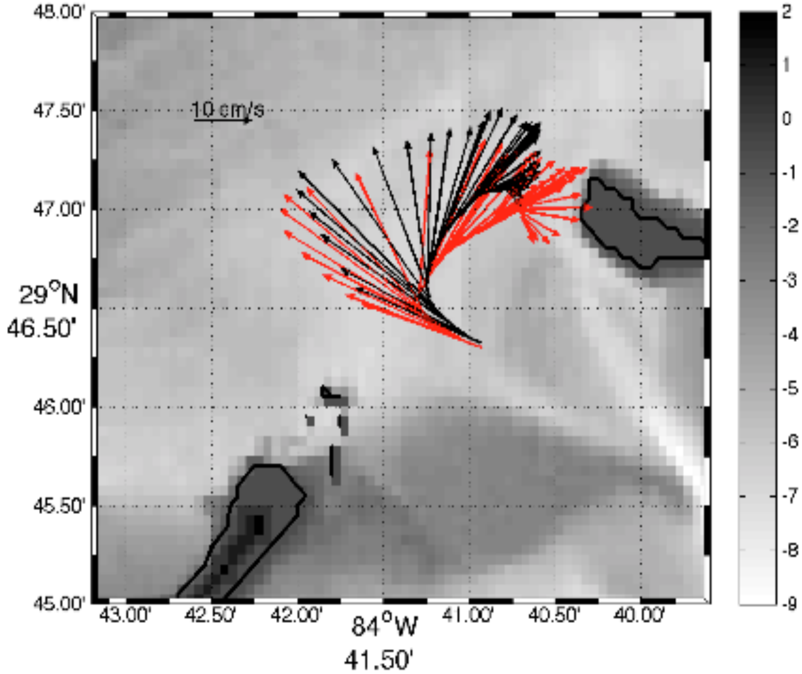


Figure 4. Timeseries of drifter velocities for Cast 1 (a) and Cast 2 (b). Note the difference in sign between casts 1 and 2 for the U velocities, indicating predominately eastward flow on the first day and predominately westward flow on the second day.

(a).



(b).

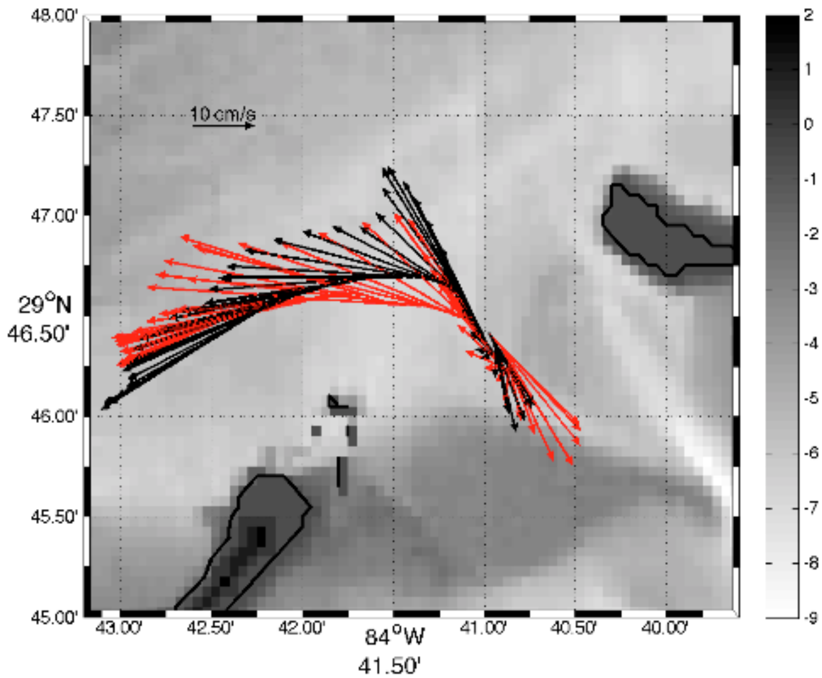


Figure 5. Velocity vectors for Cast 1 (a) and Cast 2 (b), where Drifter A is shown in red and Drifter B in black. Vector length indicates magnitude in cm/s. Note the scale vector of 10 cm/s in the upper left. Again, bathymetry (m) is contoured with lighter shading indicating deeper waters.

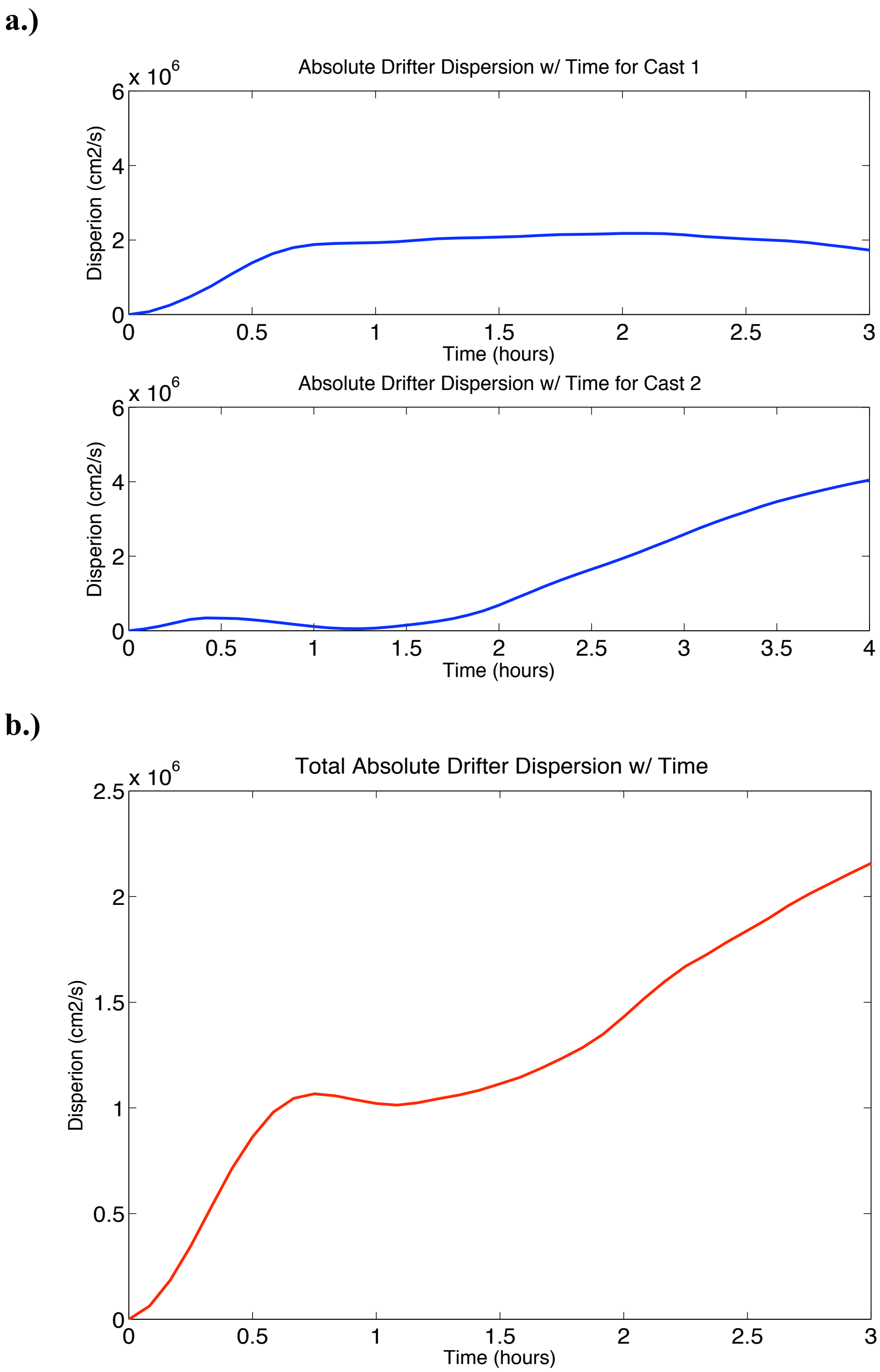


Figure 6. Absolute drifter dispersion (cm^2/s) over the course of drifter observation for casts 1 and 2 separately (a.) and for both casts averaged together (b.).

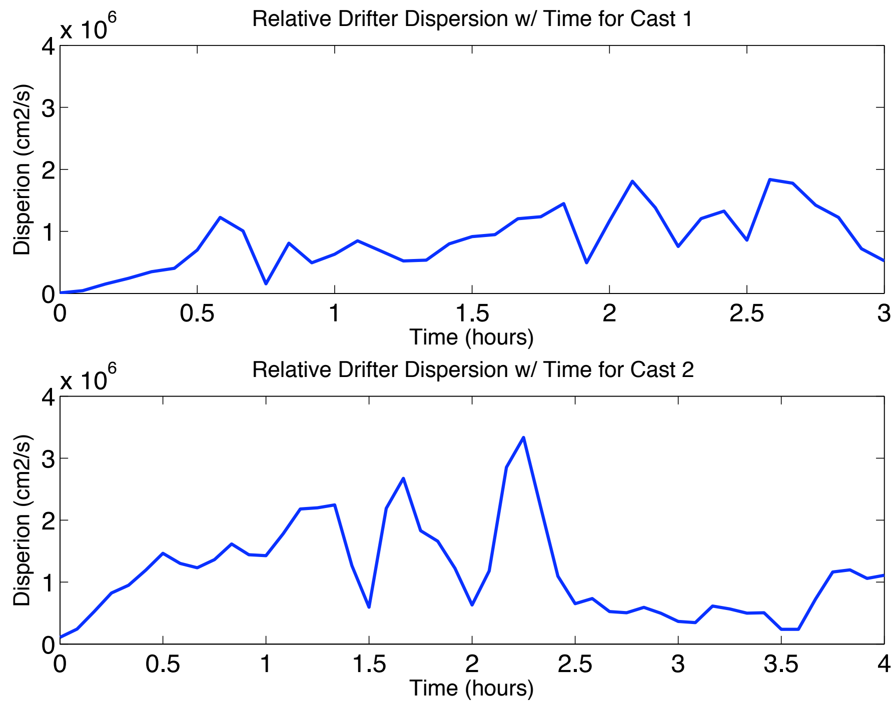


Figure 7. Relative drifter dispersion (cm^2/s), based on the relative distance between the two drifters, was computed for cast 1 (top) and cast 2 (bottom).

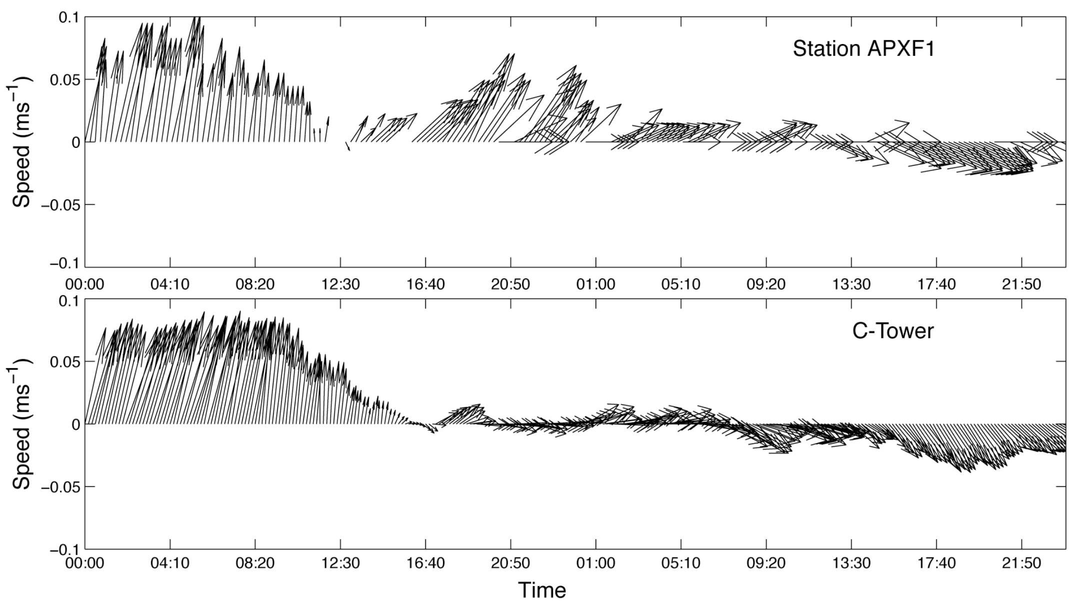


Figure 8. Timeseries of wind for NERRS Station APXF1 (top) and Tyndal AFB Tower C (bottom). Vectors represent the direction that the wind is blowing towards from 00 UTC on 9 April 2009 to 00 UTC on 11 April 2009.

CTD

Handheld YSI:

A handheld 556 multi-parameter YSI instrument was used to take measurements during two consecutive days, April 9, 2009 and April 10, 2009. Measurements were taken to observe water Salinity (ppt), water temperature (C°), and dissolved oxygen solubility (%). The handheld YSI was used at several different observation sites and data was collected at different water depths creating a profile showing salinity, temperature, and oxygen. The wire tethering the sensor to the YSI head unit was taped every 2 feet to mark depth as the handheld was lowered into the water. At each YSI sample location, longitude and latitude was recorded using the RV Bellows mounted GPS. A description of each sample section, location, methods used, and analysis are found below.

A) TSO Section:

On the morning of April 9, 2009, the boat deployed 2 drifters in the East pass channel mouth. While watching the drifters, the crew made 8 YSI observations at the surface measuring temperature (T), salinity (S), and oxygen (O). Each observation was made about 15 minutes apart. The captains of the RV Bellows choose the path starting near shallower water to the west side of the mouth, and ending in the deeper channel to the eastside of the mouth near Dog Island.

Figure A1: *Satellite view of the 8 sample TSO stations observed during drifter watch located in the East pass entrance of Apalachicola bay.*

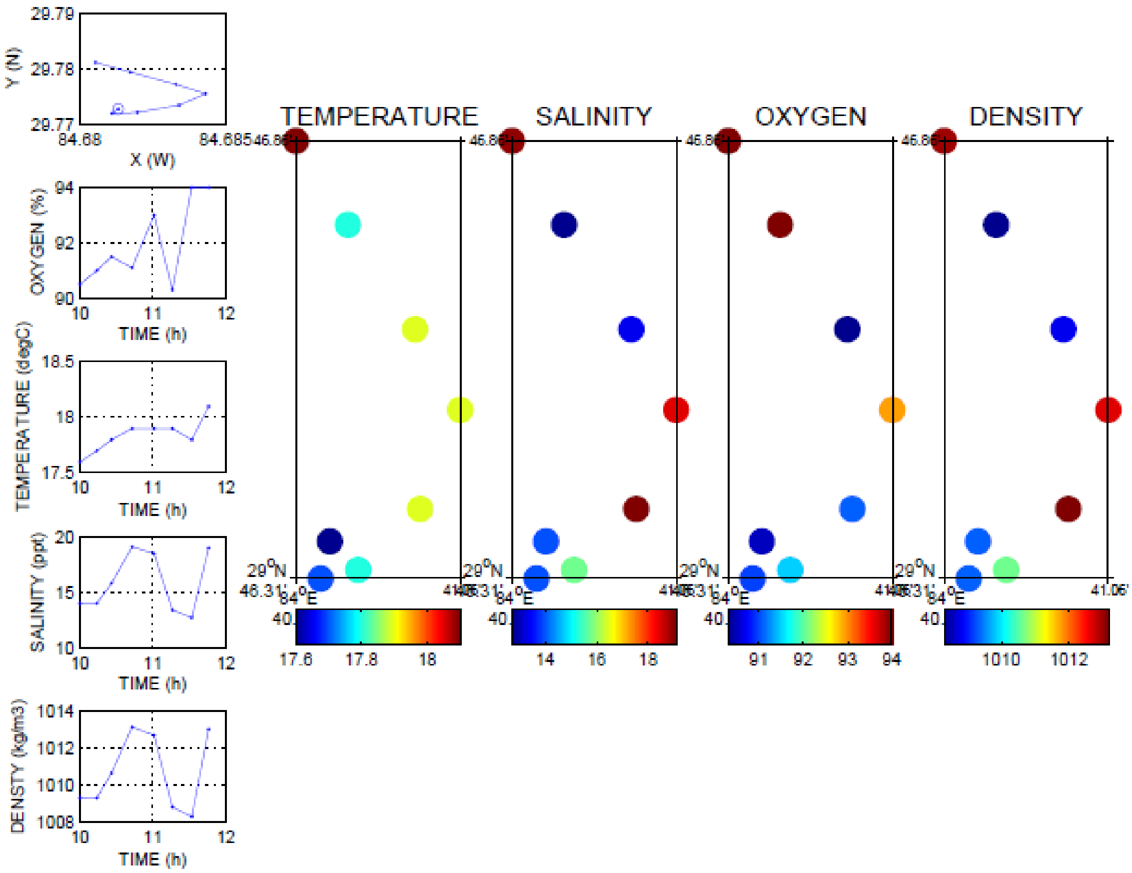


Figure A2: *Plots of TSO sample sections showing Temperature, Salinity, Oxygen, and Density for each observation point 1-8. On the left shows each parameter measured as function of time (h).*

(A) Data:

Surface observation points 1-3 are consistently low for each TSO parameter. Points 4-5 begin to start showing slight increase in temperature and oxygen. Salinity was highest at point 4 (19.1ppt) and declined from points 5 to 7. Salinity climbed back up to 19ppt at point 8. Point 8 was located in the middle of the channel which allowed for higher salinity and dissolved oxygen concentrations from stronger current flows. Point 8 had among the highest recordings for all parameters (T,S,O). Temperature varied from 17.6-18.1 °C. Salinity varied from 14-19.1 ppt. Oxygen varied from 90.3-94.0%. Average salinity of all points was 15.8ppt.

NUMB	**LAT**	**LON**	**TIME**	**TEMP(°C)**	**SALI(ppt)**	**OXYG(%)**
1	**29 46 357**	**84 40 879**	**10 00**	**17.6**	**14.0**	**90.5**
2	**29 46 310**	**84 40 866**	**10 14**	**17.7**	**14.0**	**91.0**
3	**29 46 321**	**84 40 918**	**10 26**	**17.8**	**15.8**	**91.5**
4	**29 46 398**	**84 41 004**	**10 43**	**17.9**	**19.1**	**91.1**
5	**29 46 523**	**84 41 059**	**11 01**	**17.9**	**18.5**	**93.0**
6	**29 46 625**	**84 40 997**	**11 16**	**17.9**	**13.4**	**90.3**
7	**29 46 757**	**84 40 904**	**11 32**	**17.8**	**12.7**	**94.0**

8	**29 46 863**	**84 40 832**	**11 46**	**18.1**	**19.0**	**94.0**

B) CTD stations 13-22:

On the afternoon of April 9, 2009, the RV Bellows followed a west-southwest heading going from CTD stations 13-22 in St. George Sound. At each station, the handheld YSI took measurements along side the SeaBird 911c CTD at each station. The YSI measured temperature, salinity, and oxygen at depths of 0,4,8,12,16 feet above the bottom, and at the surface. The method used for taking measurements consisted of dropping the YSI sensor to the bottom first, then measuring in increments of 4 feet on the way to the surface. First station observed was at 4:12pm (station13); last station observed was at 8:21 pm (station22).

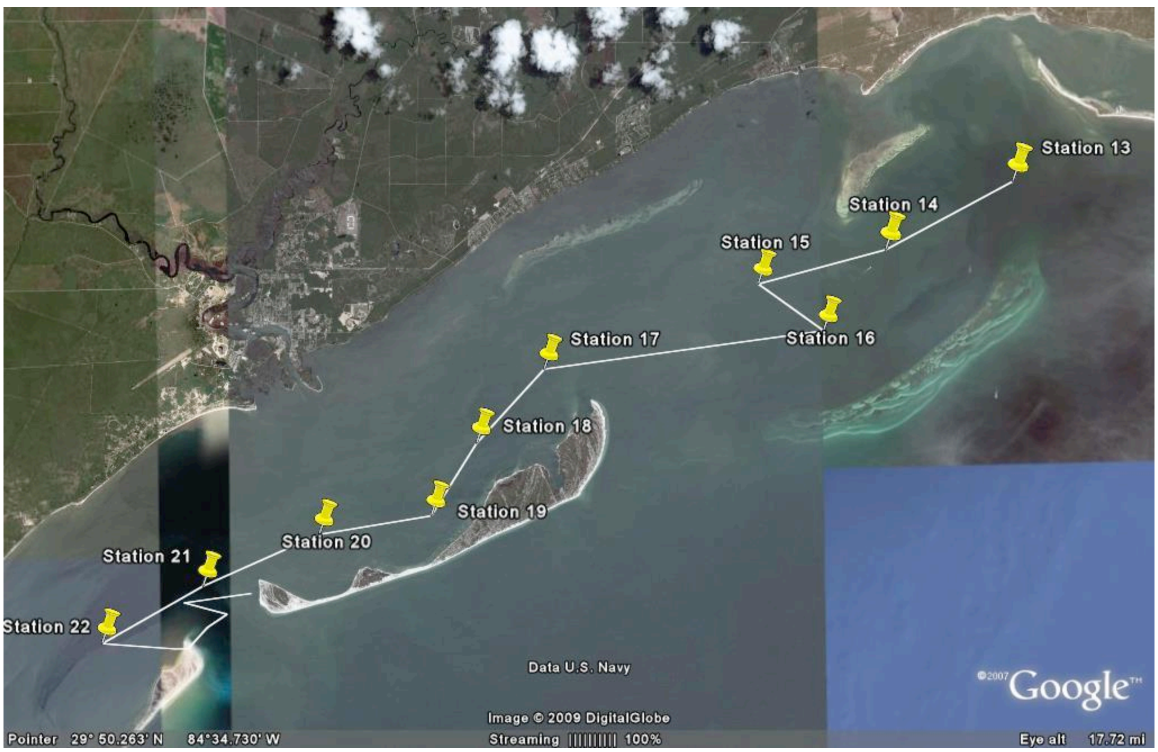


Figure B1: *Satellite view showing location of each CTD/YSI station (13-22) in St. George Sound.*

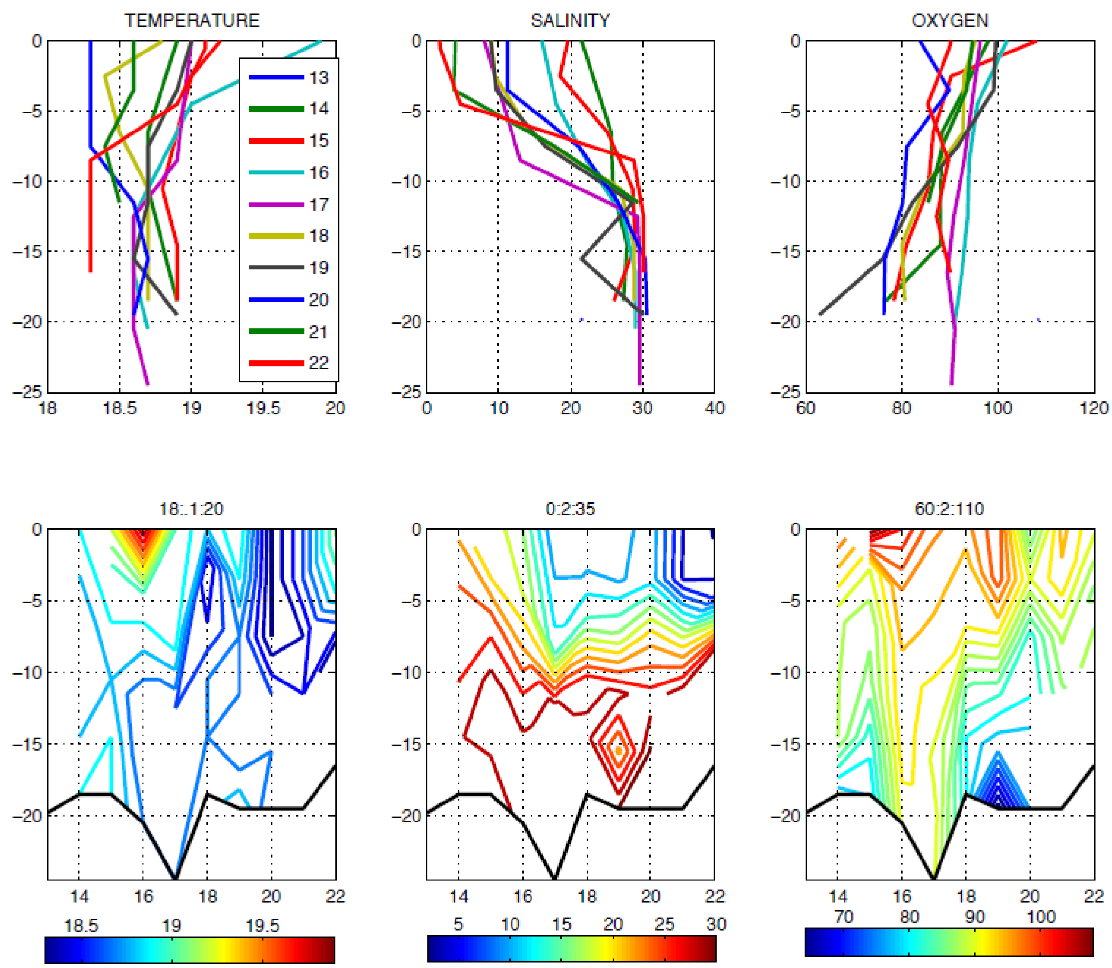


Figure B2: *Plots of the CTD stations 13-22 showing depth profiles for temperature, salinity, and oxygen. (Top): Colored lines represent individual stations and depth as Y axis; T,S,O units as X axis. (Bottom): Depth represented as Y axis and station numbers as X axis. (Note: missing data caused breaks in the graphs for some sections)*

(B) Data: Observations recorded at each station profile show little stability for each parameter throughout the water column. This instability could be a result of heavy rains over the entire panhandle of Florida that fell just several days before our scheduled cruise. The resulting extra freshwater influx from the all the local rivers feeding St. George sound provided a well-mixed salinity profile at most stations. But, generally the dense saltwater remained at the bottom while the freshwater layer stayed atop. Average surface salinity of all stations was 12.6ppt. Highest salinity variability was observed at station 22, (30.1ppt at the bottom to 1.8ppt at the surface).

Temperature remained fairly consistent for each station with the highest temperature reading at the surface, and coolest that the bottom. Highest temperature reading was 19.8°C at the surface at station 13. Station 13 was observed at 4:12pm, supporting the high water temp at that time of day. Station 22 had the coolest temperature reading of 18.3°C made at the bottom, at 8:21pm.

Dissolved oxygen was also well mixed throughout the depth profile. Oxygen concentrations were highest at the surface, and some stations showed supersaturated oxygen concentrations at the surface (dissolved oxygen above 100%). This high surface oxygen concentration could be result of wave mixing from wind shear, or simple equipment error. Reasons for this error could be that the YSI sensor contained trapped air bubbles, or if the sensor had inadequate time to adjust for an accurate reading.

C) Salinity Section through East Pass Mouth:

On the morning of April 10, 2009, a salinity section was made heading on a northwest course through the channel of the East Pass mouth. Only salinity was recorded for this section using the handheld YSI. At each observation point (1-13) a depth profile was created by taking measurements starting from the bottom, and measuring towards the surface in increments of 4 feet. Because of the location in the channel mouth, a two pound lead weight was attached to the YSI sensor to help keep the wire vertical due to the wind and currents. At each observation point, latitude and longitude was also recorded using the RV Bellows mounted GPS. Distance between each point varied, but an increment of ~200meters was attempted.

Figure C1: *Satellite view of all 13 stations through the East pass mouth where only salinity was measured at different depths.*

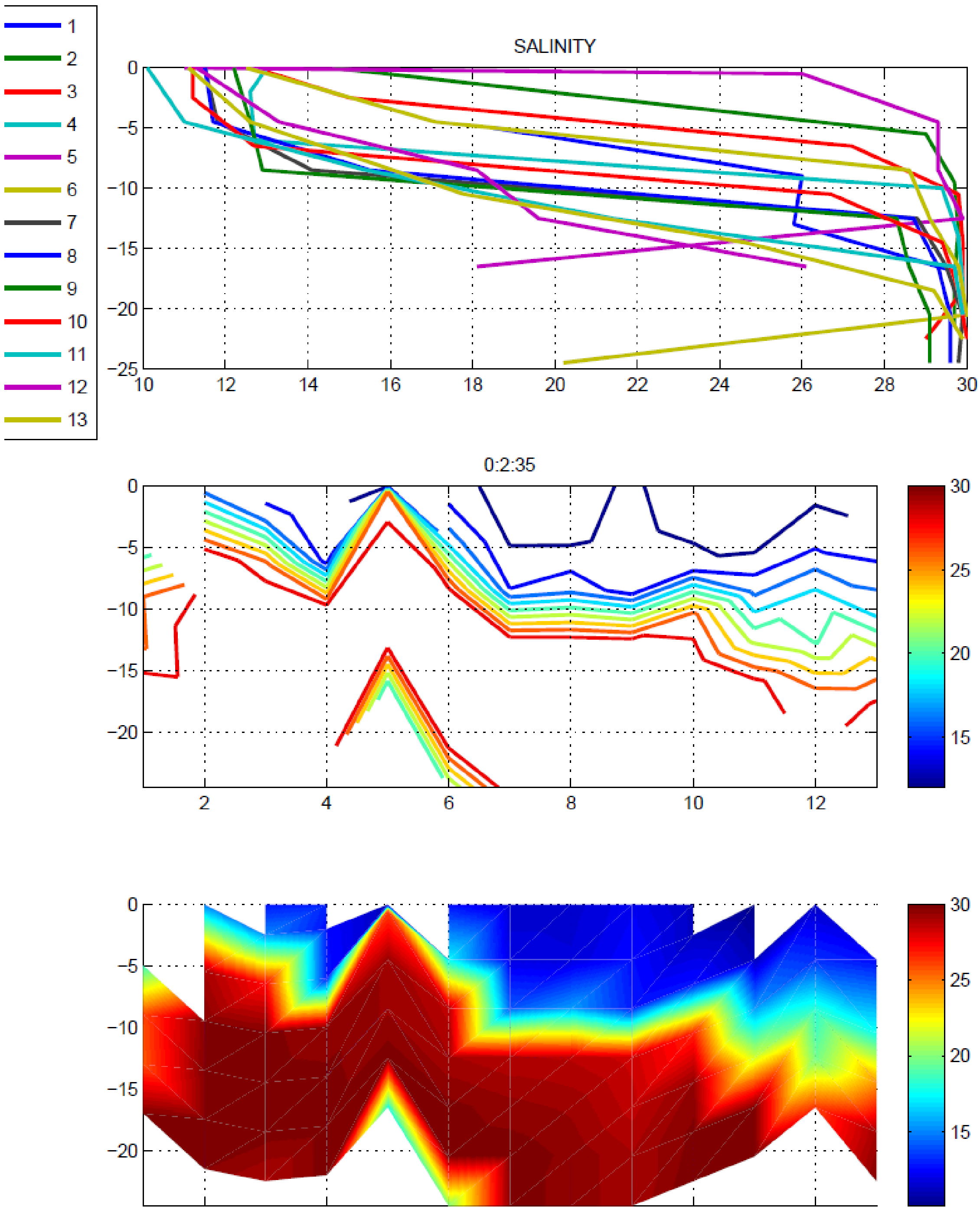


Figure C2: *Plots showing salinity as a function of depth at each observation point through East pass channel. (Note: missing data and error in depth measurement caused breaks in the graphs for some points)*

(C) Data: Observations recorded at all 13 sample points indicate a strong salinity contrast from bottom to surface. The bottom 8 feet of each sample point remained consistently high in salinity; averaging ~26ppt. The top 4 feet of each sample point was very fresh in comparison to the bottom 12-14 feet. The highest salinity concentration recorded was 30.0ppt, at point 10, 4 feet above the bottom. The lowest salinity concentration recorded was 10.1ppt, at the surface on point 11. Average surface salinity for all points was 12.1ppt. Average bottom salinity for all points was 27.8ppt. Sample points 1 through 13 were relatively consistent for salinity at each depth in the East pass mouth.

Errors:

While using the handheld YSI to measure temperature, salinity, and oxygen—the team ran into several complications. Currents and wind all played a factor on moving the boat, making it quite difficult to keep the YSI wire vertical in the water. Because of the shear drift in the YSI line, measurements of water depths from the line were not accurate. This was a problem at all observation points. The graphs above were calculated implying the wire was vertical, giving inaccurate depths. But as we witnessed, the drifting of the boat flawed the depth calculations.

Another error the team encountered was the method by which the depth profiles were approached. Each observation in the depth profile started from the bottom, and measurements were made every four feet progressing towards the surface. This method was the wrong approach because the depth of each observation point was unknown by this approach. The correct way to record these measurements would be to start at the surface, and work down every four feet until reaching the bottom. This would account for varying depths at each observation point and would allow the graphs to appear more accurate and complete.

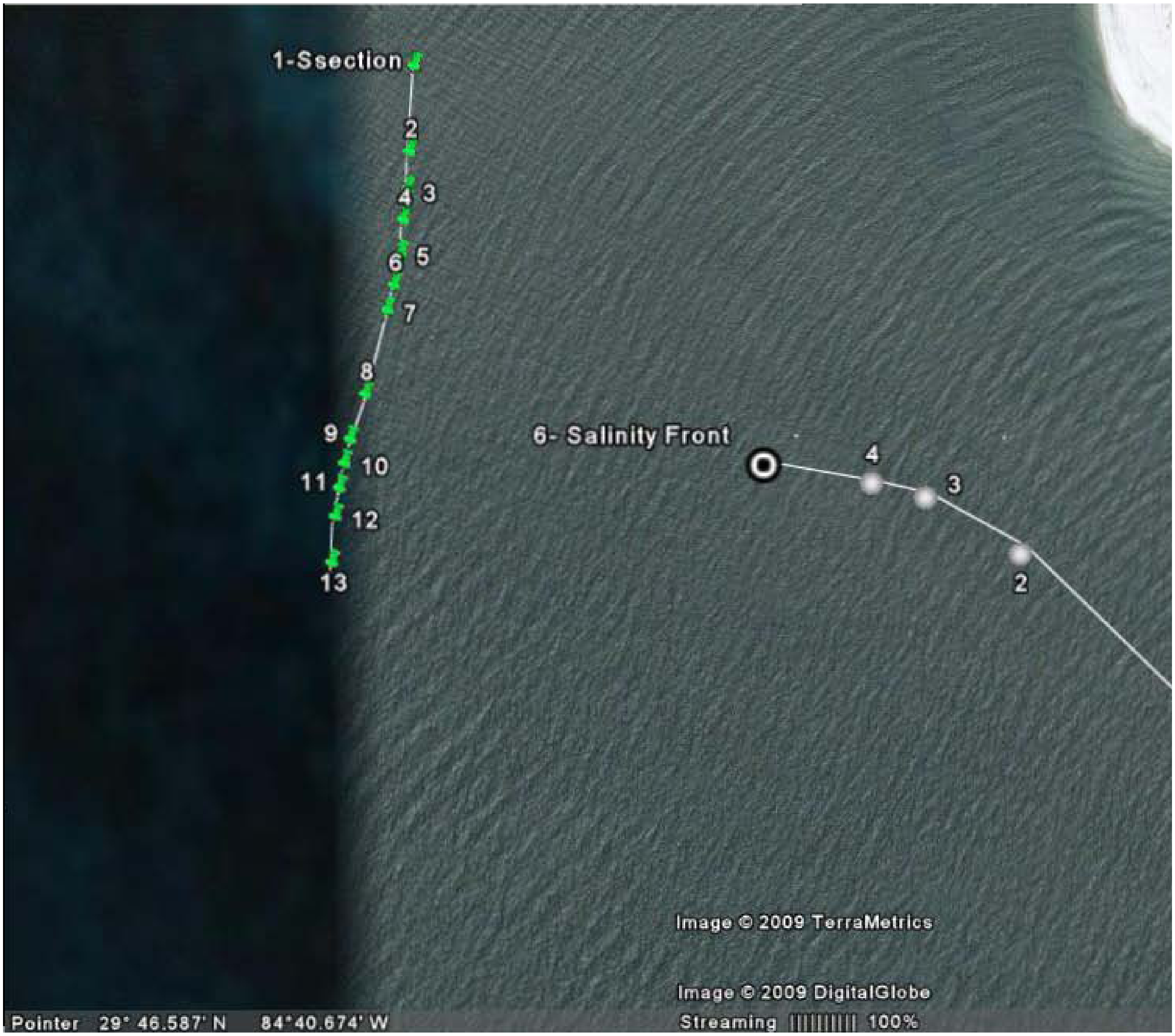
Methods

Goal of cruise is a unique opportunity to participate in the preparation and realization of an ocean science field research. We tested for parameters such as temperature, salinity, dissolved oxygen, chlorophyll, pH, turbidity, and dissolved organic matter. We also incorporated a Doppler current meter and a sediment corer into our instrumentation. A typical hydrological section of key areas were made and provided ample data of physical and chemical properties within St. George Sound.

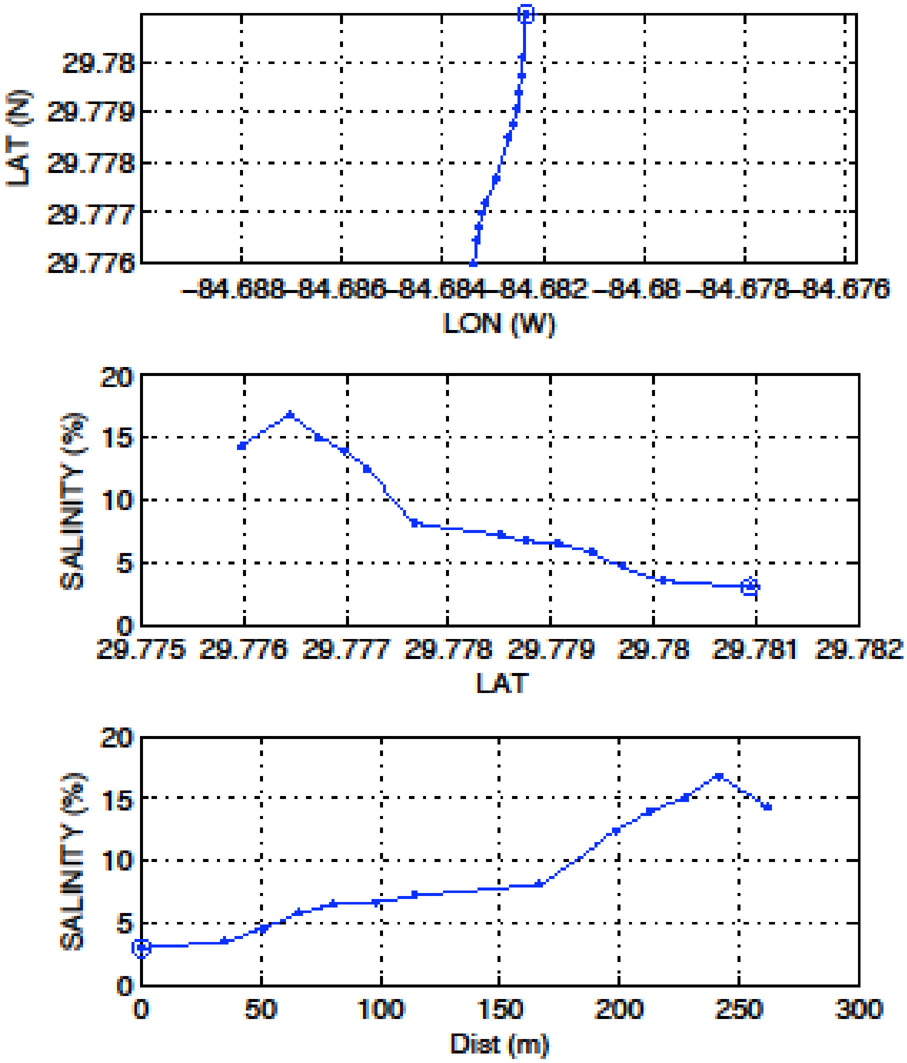
The Edge (Salinity Front)

On Thursday we came across the visible signs of a strong density gradient (pycnocline). This gradient inhibits mixing between the two water masses. We took 6 sections of data, about two minutes apart as we drifted over this boundary layer. We only obtained surface data and therefore can only predict a hypothetical column profile based on the salinity. The data does suggest that mixing is occurring under this colored layer and the color represents sediment flushed from the river and caught within the flux.

% NUM%%	LAT%%%%	LON %%	TIME %	TEMP(¡C)%	SALI(ppt)%	OXYG(%)
1	29 46 3790	84 40 3040	01 10	18.7	30.5	96.3
2	29 46 5650	84 40 5240	01 16	20.0	22.0	99.3
3	29 46 6000	84 40 5890	01 18	20.2	18.4	97.0
4	29 46 6090	84 40 6260	01 20	20.2	20.8	9999
5	29 46 6210	84 40 6970	01 23	9999	29.0	9999
6	29 46 6211	84 40 6975	01 23	9999	06.0	9999



The S section
This was a short drifting transect through the pass. The following data represents each of our 13 points of data taken**.**


LAT (N)
29.78
29.779
29.778
29.777
29.776
−84.688−84.686−84.684−84.682 −84.68 −84.678−84.676
LON (W)
SALINITY (%)
20
15
10
5
0
29.775 29.776 29.777 29.778 29.779 29.78 29.781 29.782
LAT
SALINITY (%)
20
15
10
5
0
0 50 100 150 200 250 300
Dist (m)

CORER: BENTHIC PHOTOSYNTHESIS MEASURED FROM THE R/V BELLOWS

Introduction

Photosynthesis is an extremely important biological process that uses certain wavelengths of light to drive chemical reactions and create biomass. For the most part, this is sequestration and conversion of carbon dioxide into an organic hydrocarbon. This reaction cleaves oxygen off of carbon atoms and leads to the production of oxygen gas. Thus, measuring the change in concentration of dissolved oxygen gas in a volume of water is an appropriate proxy for quantifying how much photosynthesis is occurring.

In the coastal ocean, photosynthesis can be done by seagrass, macroalgae, dinoflagellates, or cyanobacteria, but it is done in large part by diatoms. These photosynthesizers may be floating in the water column, but may also fall down onto or grow out of the bottom. Having a substrate available can provide these organisms the means to grow in a much higher concentration. It is becoming apparent that the seafloor in light-exposed environments can play a major role in photosynthesis in the ocean. It is important to measure how much photosynthesis is done by the sediment alone in order to understand its contribution on a larger scale.

Methods

Off the R/V Bellows, we deployed a coring unit using a winch in Apalachicola Bay, at latitude 29° 48.357'N and longitude 84° 40.390'W. The corer is a large steel rig with four core liners at the bottom. As the unit is lowered into the sediment, lead weights help push the liners into the ground. Once the winch line goes slack, a metal pin that was held in place by the tension is released, and the corer is set. When the winch line goes taut again to bring it back to the surface, the corer is triggered. This releases rubber pads on top to seal the tops of the cores, and rubber pads on spring-loaded arms swing down into the sediment. As the corer is pulled out of the sediment, these lower rubber pads are scooped under the core liners and seal the cores from below. This provides us with perfectly sealed cores of the bottom surface that maintain the stratification and structure of the sediment as it was present in situ.

The four cores collected were immediately pulled out of the corer, and dissolved oxygen in the overlying water of the core was measured using an oxygen optical sensor. Each core was then sealed using Petri dishes and Bostik putty. When trying to measure the photosynthetic activity by a change in oxygen concentration, it is important to keep in mind that there are still aerobic organisms in your sample. We prepared an experiment to measure the change in oxygen in the cores kept in the light and also in cores kept in the dark. If there is no light present, there is no photosynthesis going on, thus we can measure the oxygen consumption done purely by the aerobes. Two of the cores were set out on the deck where they would get plenty of sunlight, and the other two were kept in a black plastic bag in an attempt to block out all of the sunlight they would receive. After about six hours, the cores were opened up, and the dissolved oxygen was once again measured.

To compare how important photosynthesis done by the sediment is, we must also measure how much photosynthesis is done in the water column. Photosynthesis may change at depth in with absorption of light or a change in temperature. A change in depth may mean a change in the community of photosynthesizers. We took water samples at the deepest location on our cruise plan: about 18 miles off shore from St. Teresa near a large structure built by the Air Force known as "K-tower" (29° 40.419'N, 84° 21.978'W). Niskin bottles were lowered in the water and samples were taken at 20m, 10m, and at the surface (about 1m). For each depth, two glass bottles (1 liter each) were filled: one representing light conditions and one representing dark. Like the cores, for each bottle initial dissolved oxygen concentrations were taken, then they were sealed with glass stoppers, and half of the bottles were left on the deck while the other half were left in a cooler to simulate dark conditions. After about three hours and 30 minutes, we opened the bottles and took final oxygen concentrations.

To measure how much light the cores and water bottles exposed to the light experienced, we set up a light logger that measures photosynthetically active radiation (PAR) on a nice open sunny spot on the boat. PAR is a range of light from 350 to 700nm wavelength that is considered to be pretty much the only light that is used for photosynthesis.

Results

The results from the productivity measurements from the water and sediment cores are shown in **table 1**. Note that every sample experienced an increase in oxygen concentration, even the samples kept in the dark. If there is no light, there is no photosynthesis, thus there can be no more oxygen produced. Unfortunately, this means the values for the dark cores and water samples are invalid measurements of how much oxygen consumption occurs.

Each core took 11.46cm^2 surface area of the sediment surface. This was used to convert the productivity seen in the cores to represent the bottom productivity in terms of %sat.$O_2 \cdot min^{-1} \cdot m^{-2}$. In order to convert the water samples into this 2-dimensional label, the water samples were designated as representatives for a range of depths: surface from 0 to 7m, mid from 7 to 14m, and bottom from 14 to 20m. The total productivity of these ranges per square meter of ocean was calculated and compared to the surface area of sediment (**table 2**). The production of oxygen per square meter of ocean for the total water column is 533 %sat.$O_2 \cdot min^{-1} \cdot m^{-2}$ while the average calculated production of the sediment is 9.08 %sat.$O_2 \cdot min^{-1} \cdot m^{-2}$. This makes the sediment contribute about 1.7% of the total photosynthesis at K-tower, assuming the sediment collected from Apalachicola Bay is similar to K-tower's sand.

The comparison of the raw production slopes measured between the different depths of water samples is shown in **fig. 1**. The deep water showed the most production, followed by the surface water, and the mid-level water showed the lowest production.

Discussion

The dark experiments did not work. If the samples were kept in total darkness, it isn't possible for there to be any more production of oxygen. It is possible that the black plastic bag or the cooler let some light through, or it could be that the glass stopper or Bostik putty do not create enough of a seal and let oxygen in from the air, or it could be that being on the boat, the samples were warmed up and this somehow changed the concentration of oxygen in the samples. Whatever the reason, the aerobic consumption could not be determined from any of the samples.

As might be expected, the mid-level water showed less oxygen production than the surface water. With lower light conditions, there are probably less diatoms living in the mid-level water than at the surface. However, it is interesting that the highest rate of photosynthesis was measured from the deep sample. This could mean the sample had suspended sediment in it, providing more diatoms than would normally be in the water alone. It could also mean that the diatoms found in the deep water are more efficient. It is expected that the light is the lowest in the deep water. The diatoms there may have to adapt and be really good at photosynthesis because they don't get as much light as their surface brethren. When we measured the photosynthesis on the deck of the Bellows, the diatoms were exposed to surface light conditions, which may be way more than they're accustomed to.

Nonetheless, we did see the net effects of photosynthesis on the sediment and water samples during a period of natural daylight. It would appear that in places with some reasonable depth, the main source of oxygen is produced by diatoms in the water column. This is because the water is transparent and represents a volume of photosynthesizers while the sediment represents a 2-dimensional sheet. Still, in a large-scale sense, if the sediment contributes 1.7% of the oxygen coming out of the ocean, that volume of oxygen may not be trivial.

	lat:29 40.419'		**Long: 84 21.978'**			
Water	start O2 %	end O2 %	time (min)	start temp	end temp	slope (o2% / min)
deep light	99.6	105	150	18	20	0.0360
mid light	98.7	101.1	150	18	20	0.0160
surf light	99	103.4	150	18	20	0.0293
deep dark	99.1	108	160	18	19.8	~~0.0556~~
mid dark	98	99.9	160	18	19.6	~~0.0119~~
surf dark	99.2	100.1	160	18	19.4	~~0.0056~~
	lat: 29 48.357'		**lon: 84 40.390'**			
Core						
light1	96.6	100.8	376	18	19.2	0.0112
light2	94.4	98	373	18	19.6	0.0097
dark1	93.4	98.3	376	18	18.6	~~0.0130~~
dark2	86.1	92.7	374	18	18.4	~~0.0176~~

Table 1: oxygen % saturation measurements for water samples taken at K-tower and sediment cores taken from Apalachicola Bay. Productivity is represented by % saturation change per minute. All slopes for dark samples are positive, which makes them invalid for consumption rates.

Water	Productivity (% sat. O2 · min-1 · m-2)	representing depth range
deep light	216	14 - 20
mid light	112	7 - 14
surf light	205	0 - 7
Core		
light1	9.74	
light2	8.42	

Table 2: Productivity of sediment and water column assumed from samples taken on the Bellows displayed in a 2-dimensional contribution.

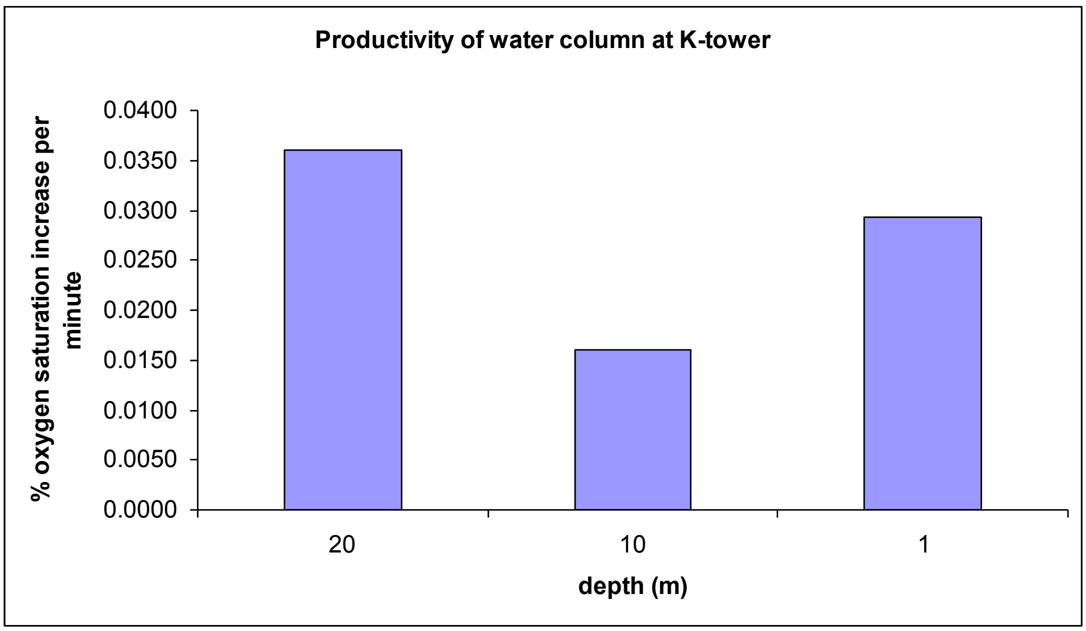
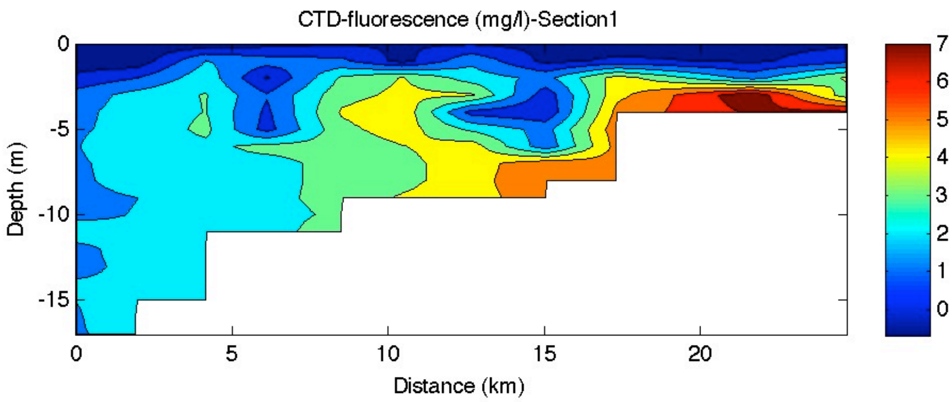
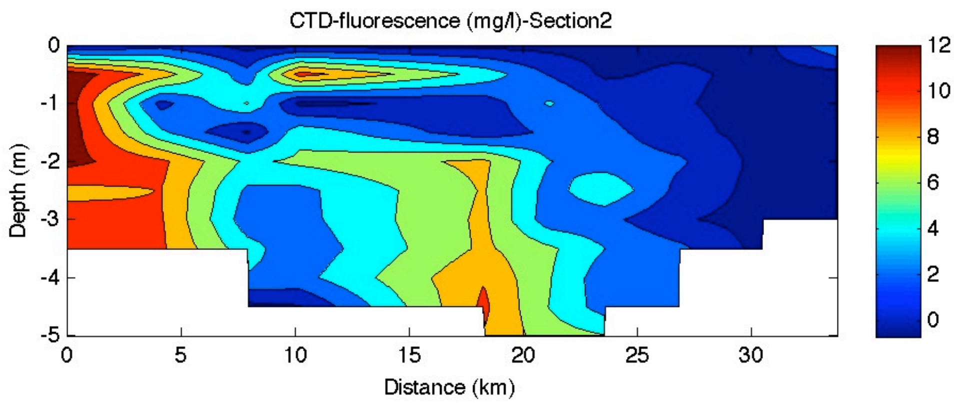
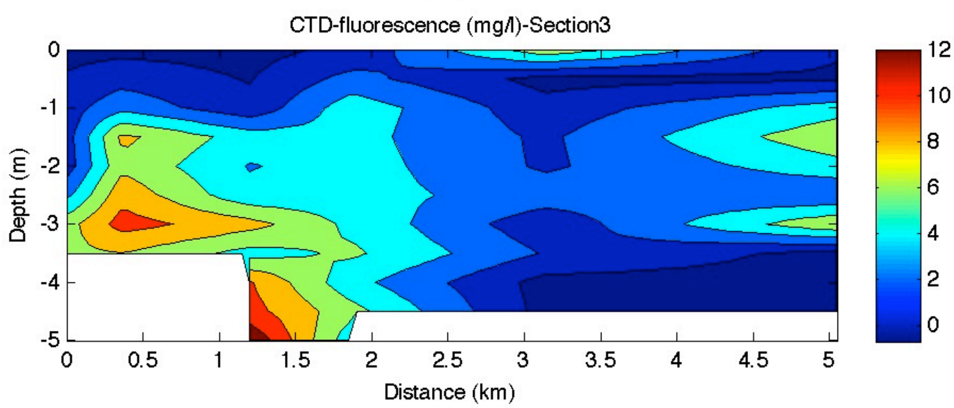


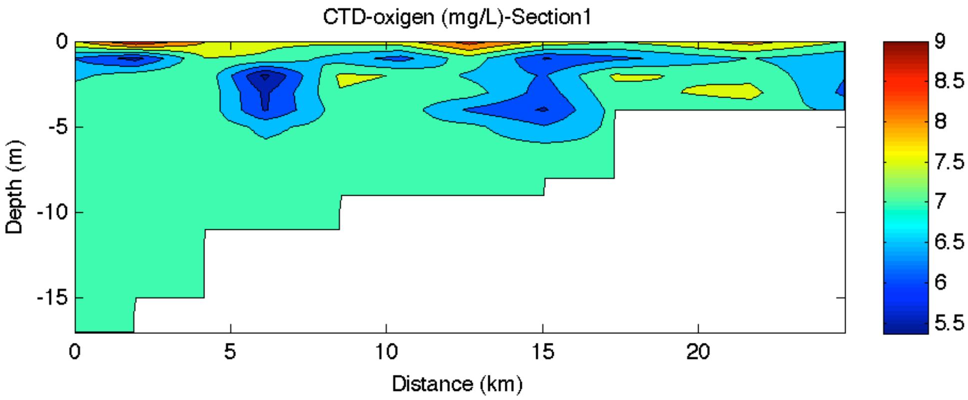
Figure 1: Raw % saturation oxygen increases are compared between the three different depth water samples left out in the sun.

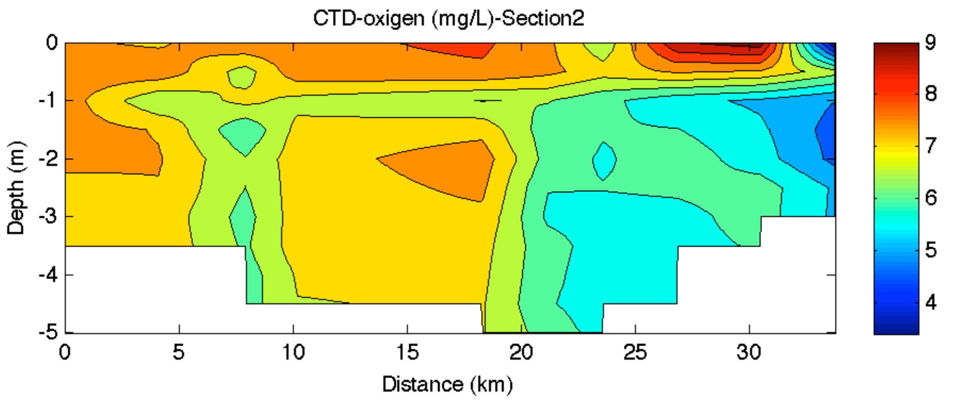
APPENDIX (plots)

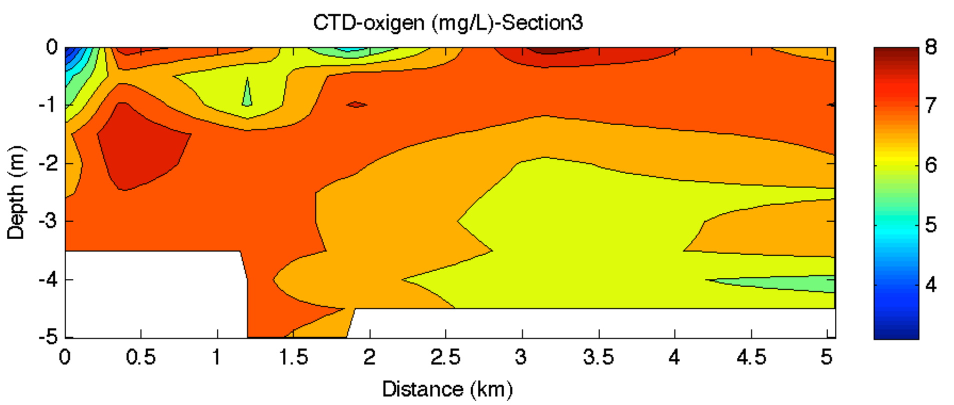




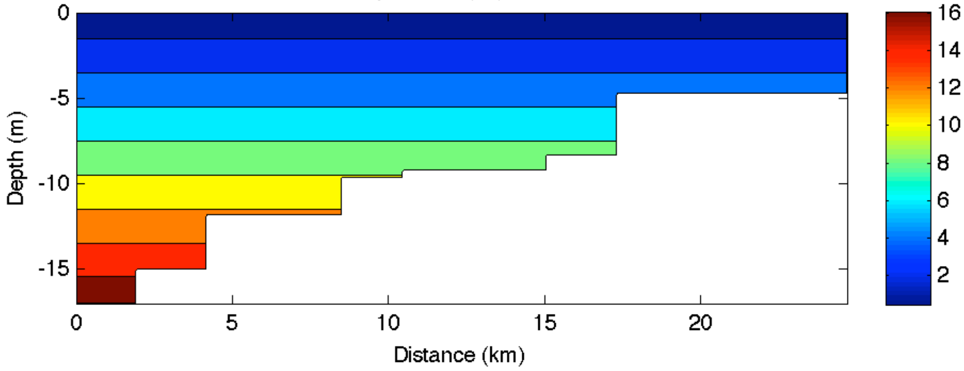



CTD-oxigen (mg/L)-Section1
Depth (m)
Distance (km)
0
-5
-10
-15
0
5
10
15
20
9
8.5
8
7.5
7
6.5
6
5.5

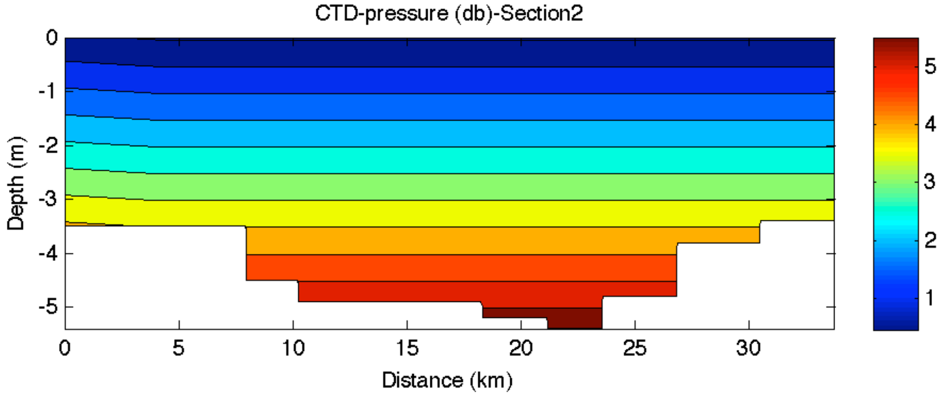

CTD-oxigen (mg/L)-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
9
8
7
6
5
4


CTD-oxigen (mg/L)-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
8
7
6
5
4

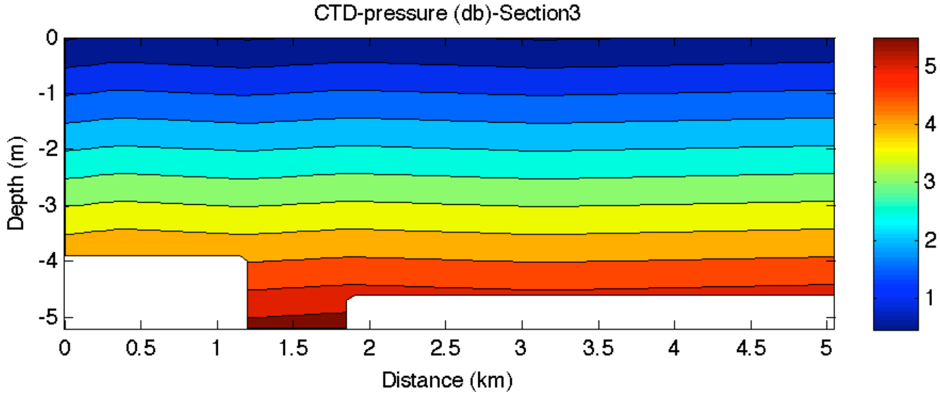
CTD-pressure (db)-Section1

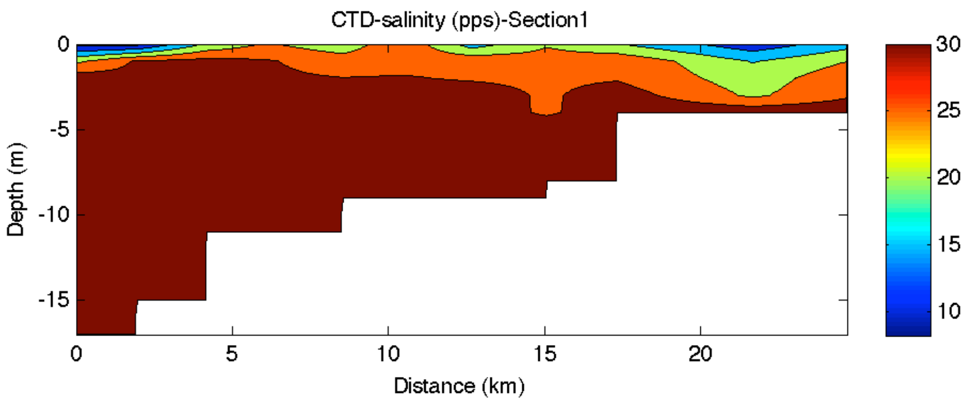


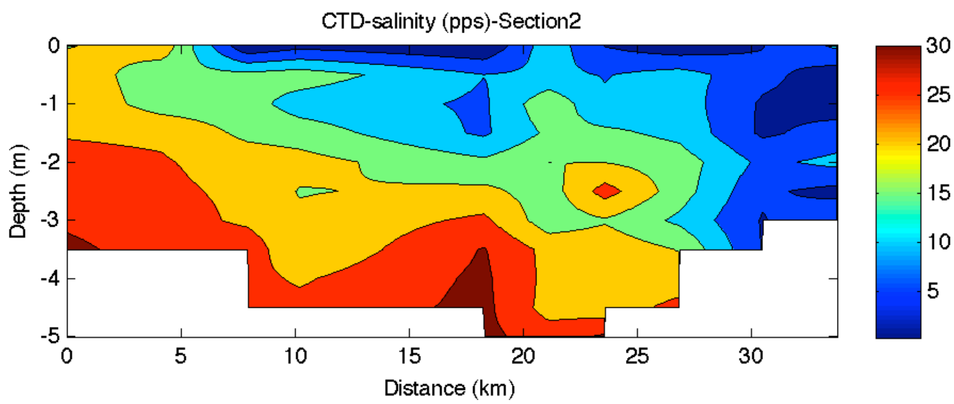
CTD-pressure (db)-Section2

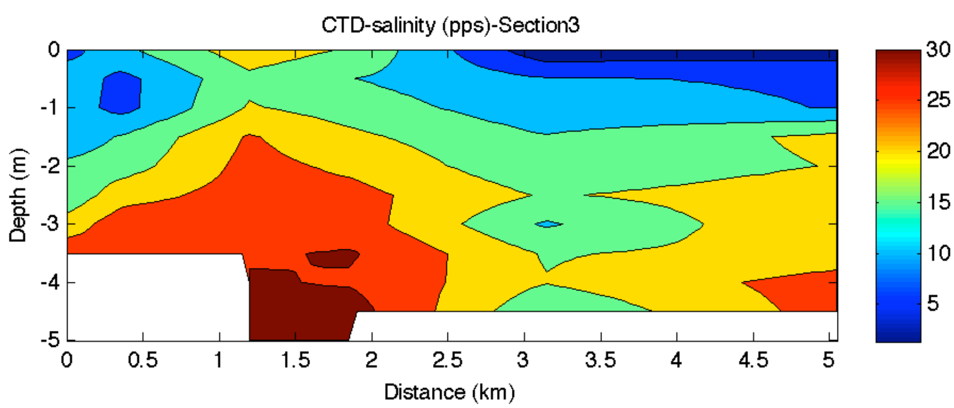


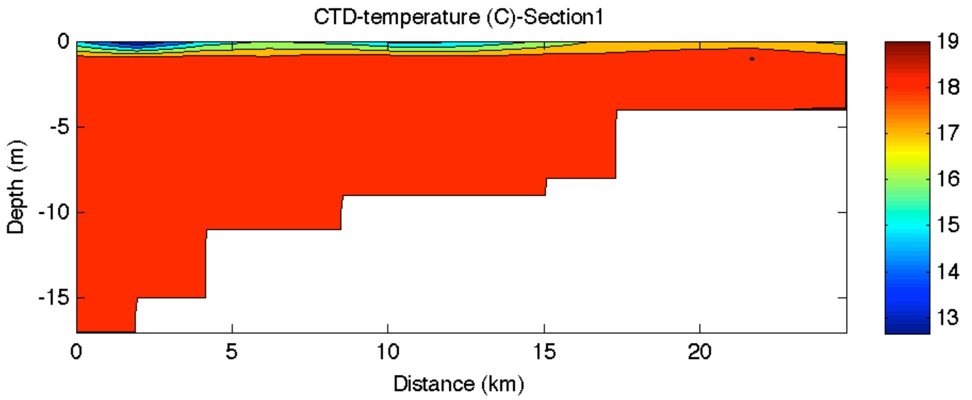
CTD-pressure (db)-Section3

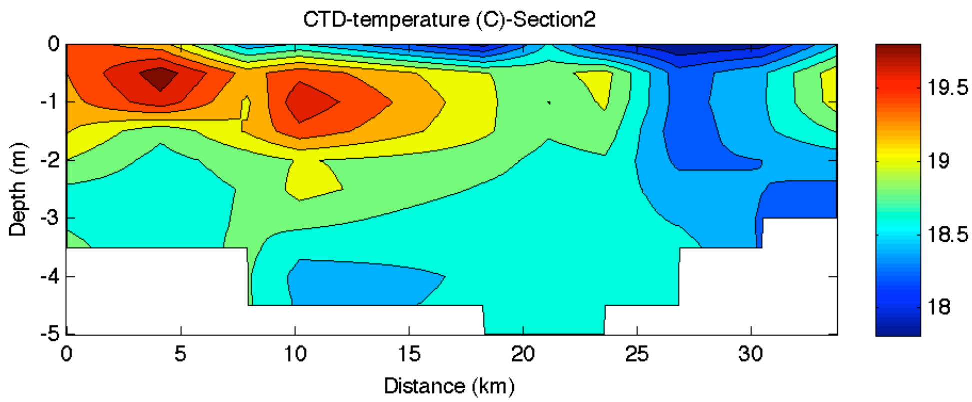


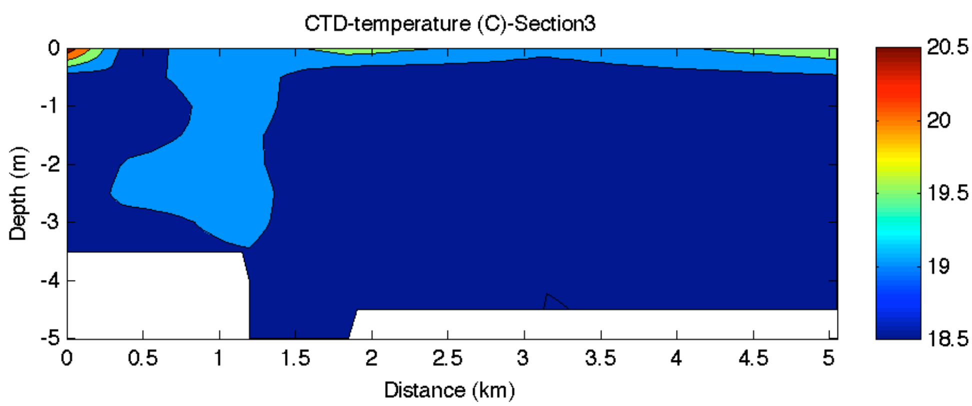

CTD-salinity (pps)-Section1
Depth (m)
0
-5
-10
-15
0
5
10
15
20
Distance (km)
30
25
20
15
10

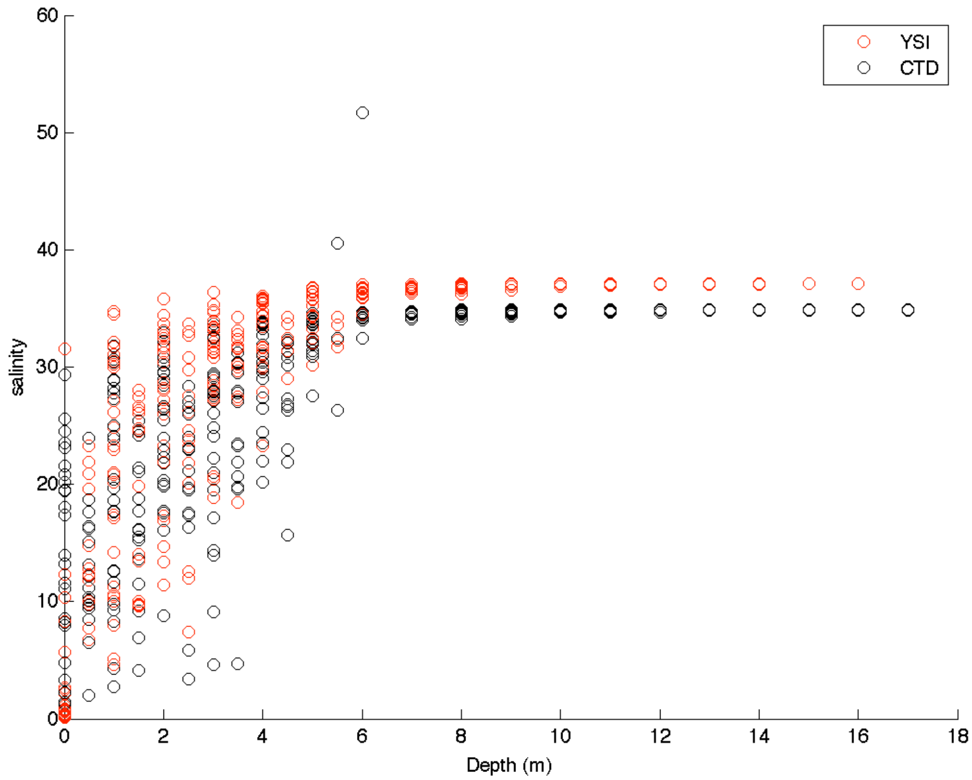

CTD-salinity (pps)-Section2
Depth (m)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
Distance (km)
30
25
20
15
10
5

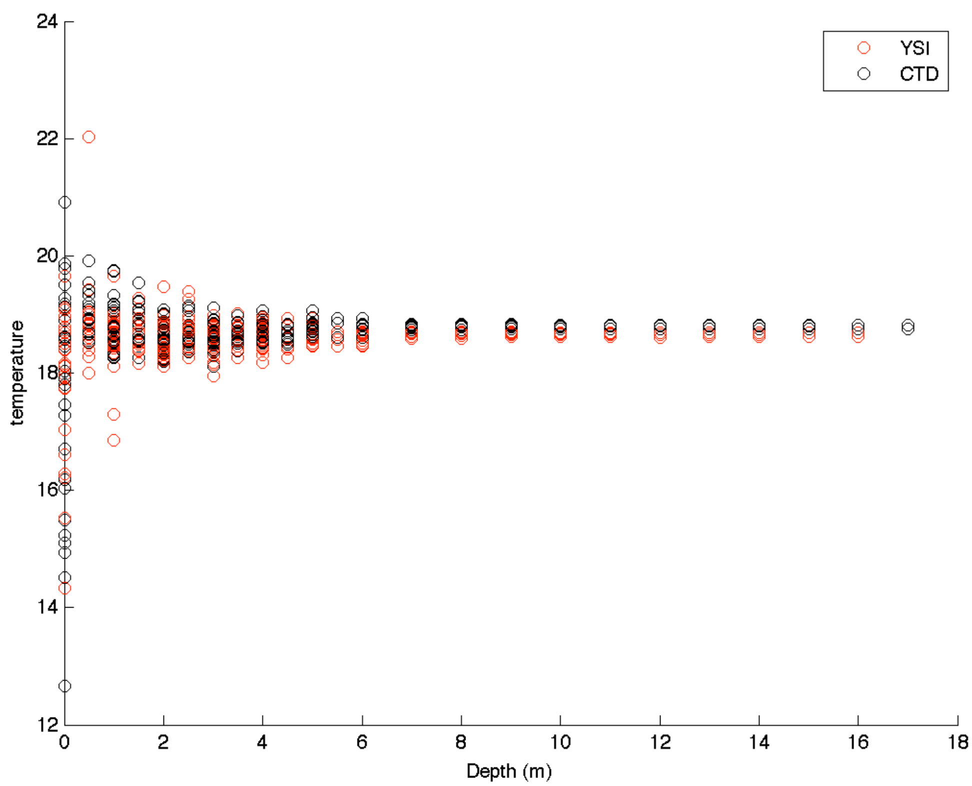

CTD-salinity (pps)-Section3
Depth (m)
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Distance (km)
30
25
20
15
10
5

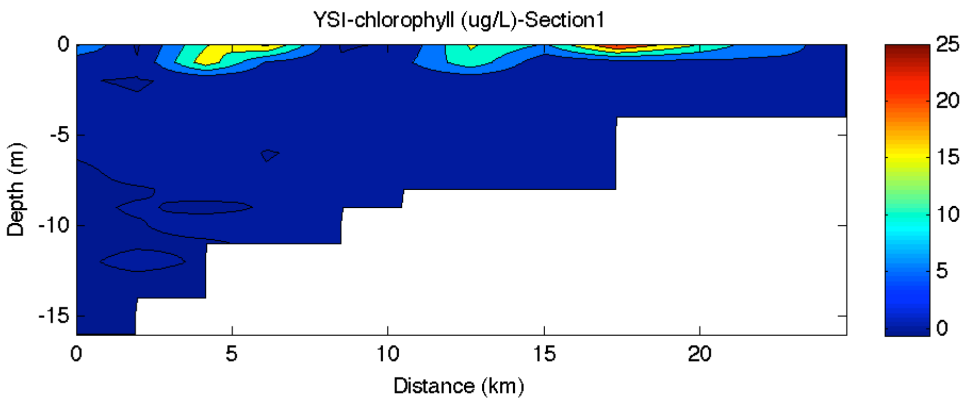

CTD-temperature (C)-Section1
Depth (m)
Distance (km)
0
-5
-10
-15
0
5
10
15
20
19
18
17
16
15
14
13

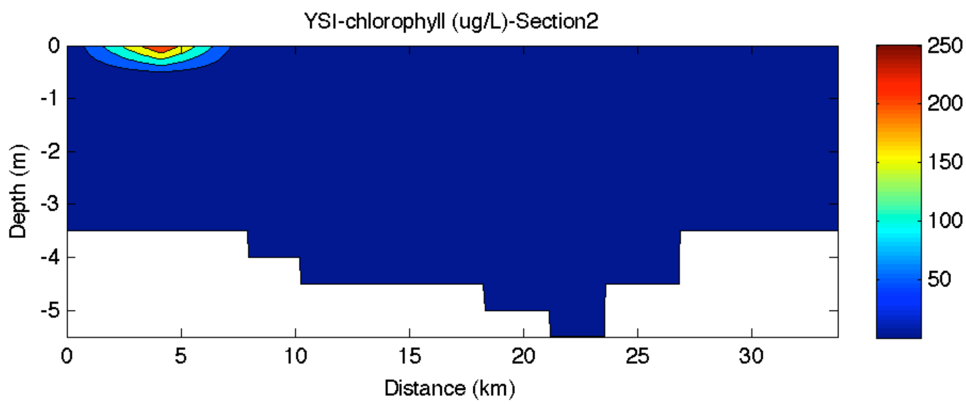

CTD-temperature (C)-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
19.5
19
18.5
18

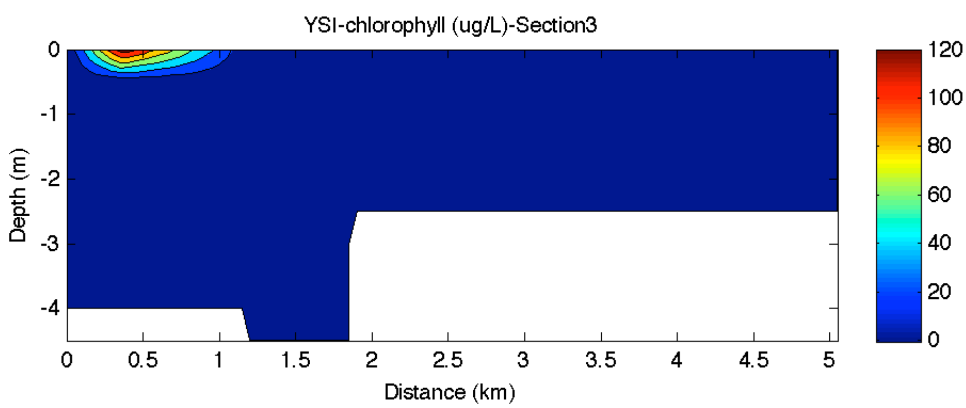

CTD-temperature (C)-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
20.5
20
19.5
19
18.5

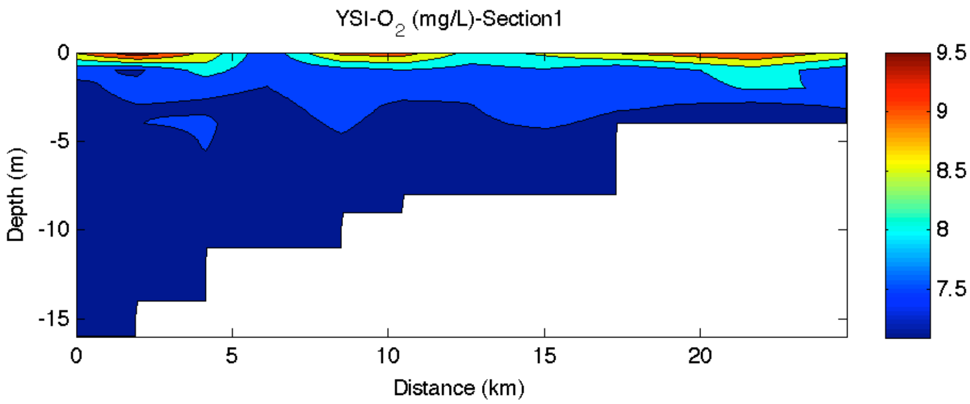

YSI
CTD
salinity
Depth (m)
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60


YSI
CTD
temperature
Depth (m)
0
2
4
6
8
10
12
14
16
18
12
14
16
18
20
22
24


YSI-chlorophyll (ug/L)-Section1
Depth (m)
Distance (km)


YSI-chlorophyll (ug/L)-Section2
Depth (m)
Distance (km)


YSI-chlorophyll (ug/L)-Section3
Depth (m)
Distance (km)


YSI-O2 (mg/L)-Section1
Depth (m)
Distance (km)
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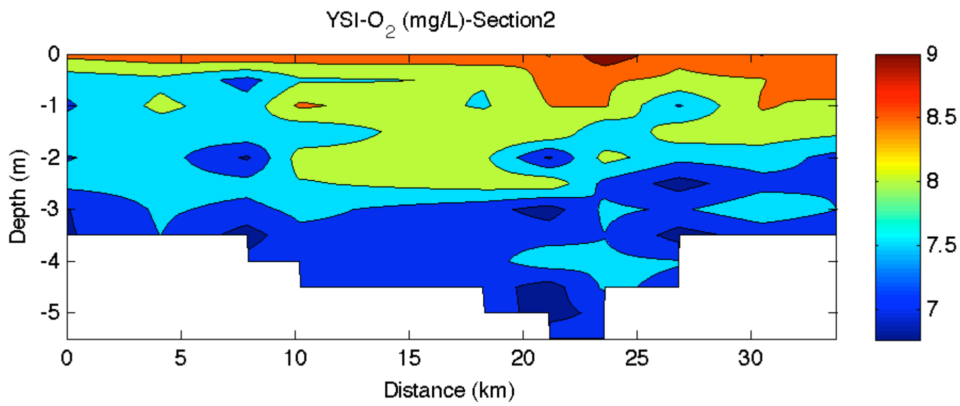
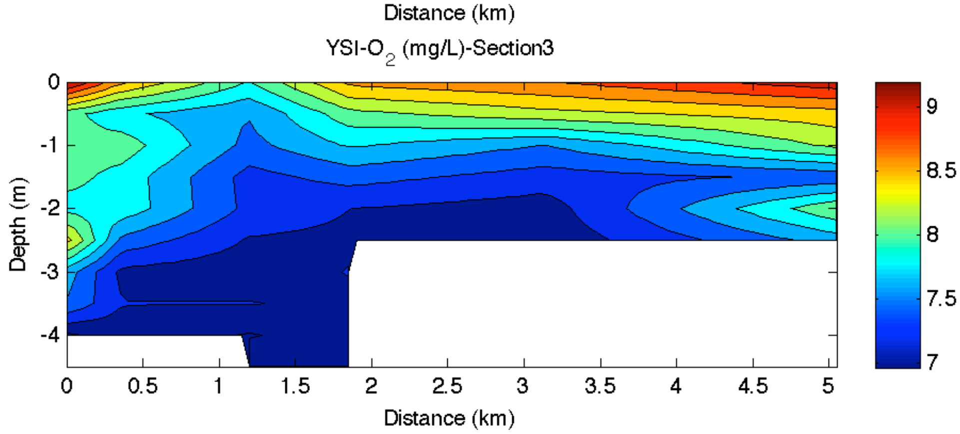
-5
-10
-15
0
5
10
15
20
9.5
9
8.5
8
7.5


YSI-O2 (mg/L)-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
9
8.5
8
7.5
7


YSI-O2 (mg/L)-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
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2
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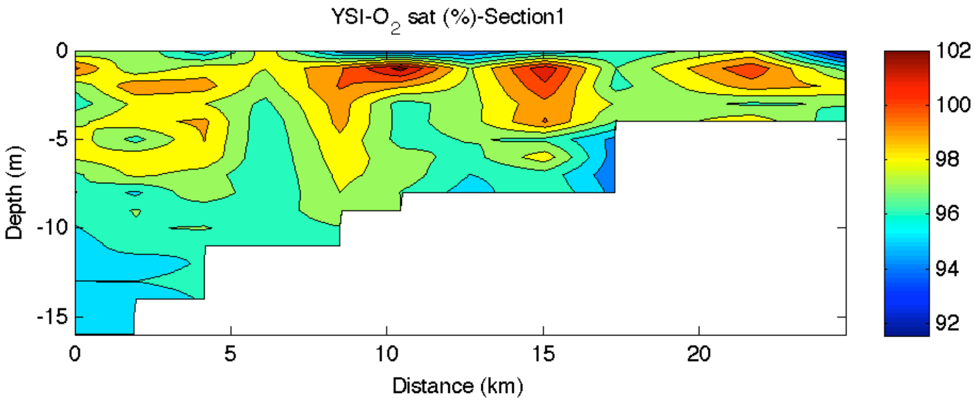
3
3.5
4
4.5
5
9
8.5
8
7.5
7


YSI-O2 sat (%)-Section1
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Distance (km)
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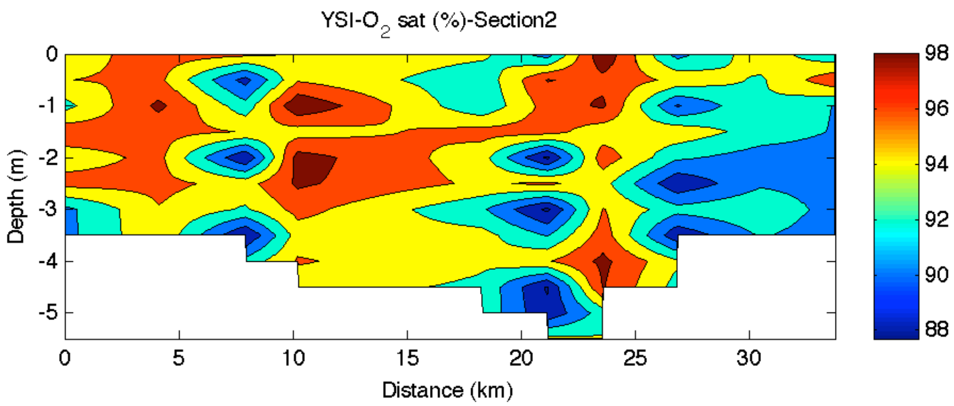
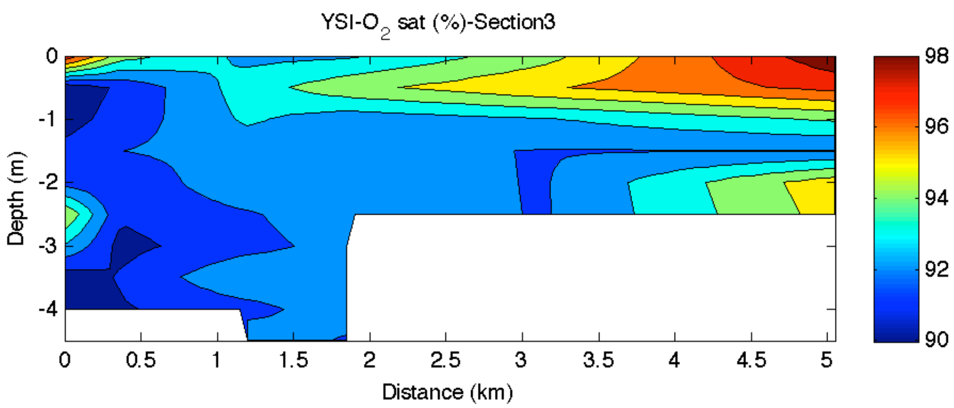
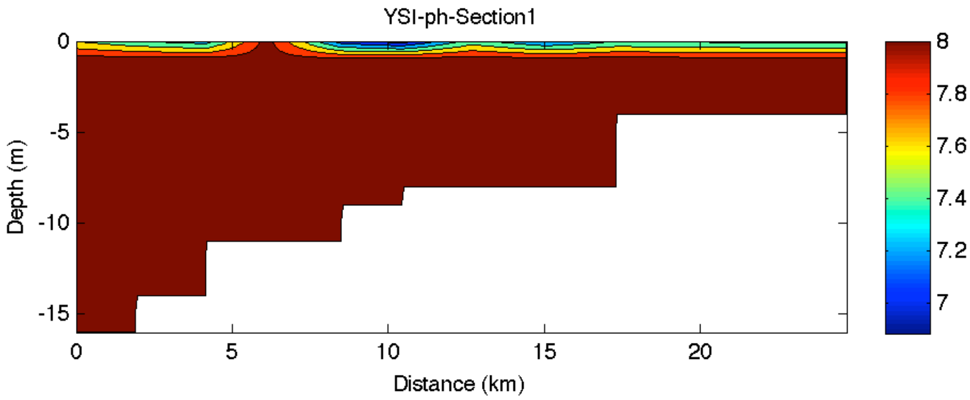
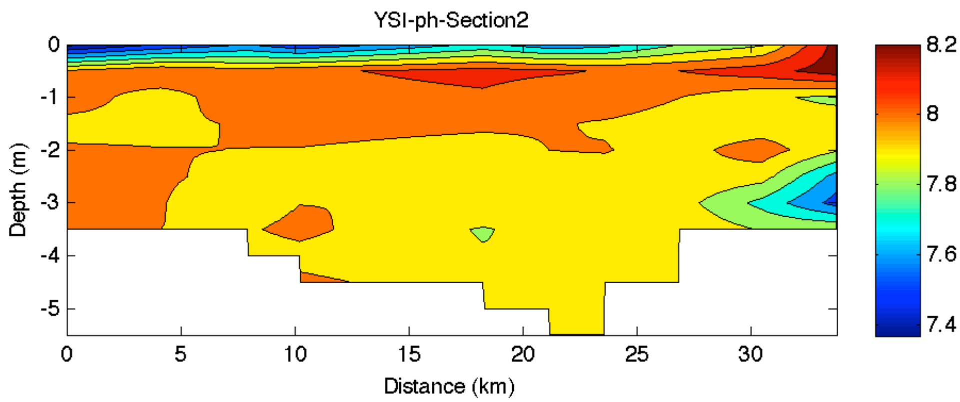
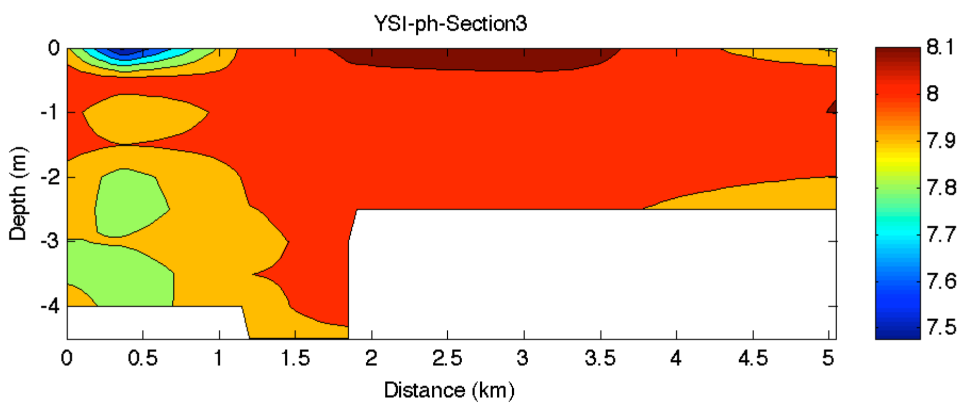
-5
-10
-15
0
5
10
15
20
102
100
98
96
94
92

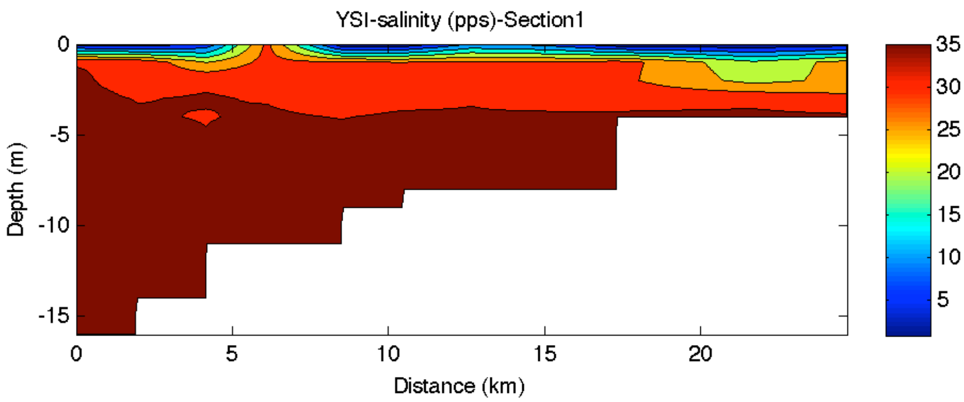

YSI-O2 sat (%)-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
98
96
94
92
90
88

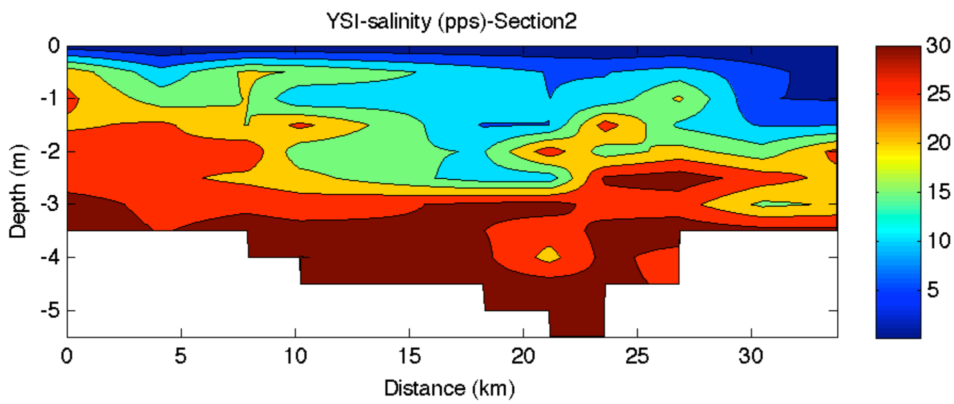

YSI-O2 sat (%)-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
98
96
94
92
90

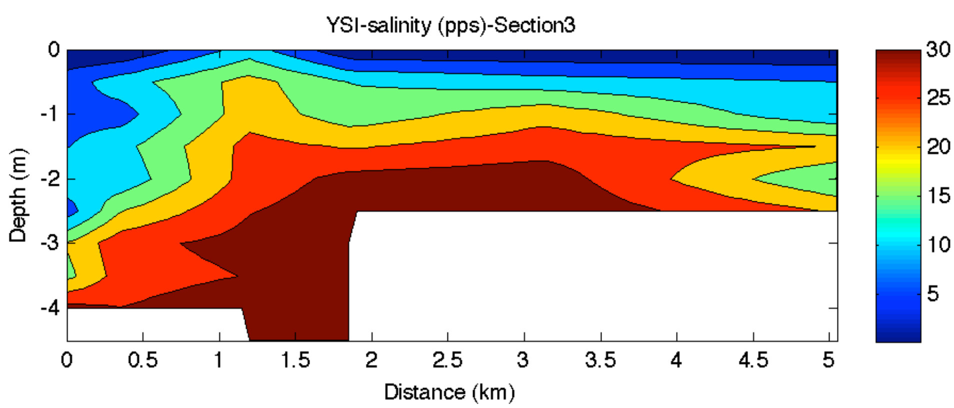

YSI-ph-Section1
Depth (m)
Distance (km)
0
-5
-10
-15
0
5
10
15
20
8
7.8
7.6
7.4
7.2
7

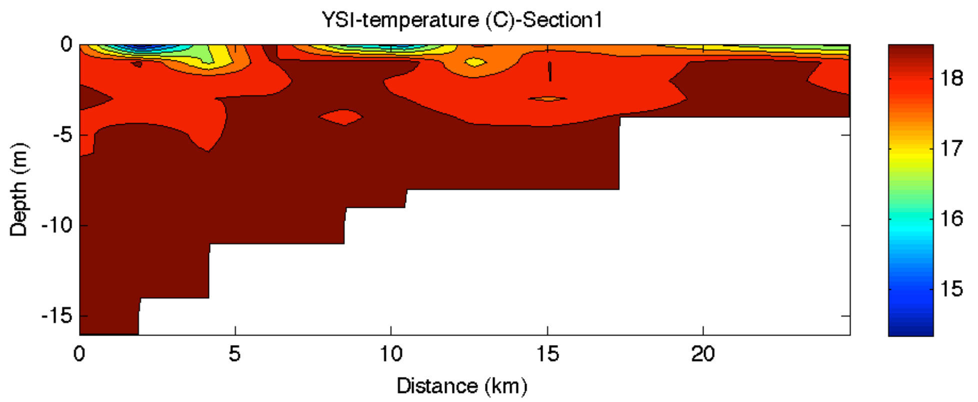

YSI-ph-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
8.2
8
7.8
7.6
7.4

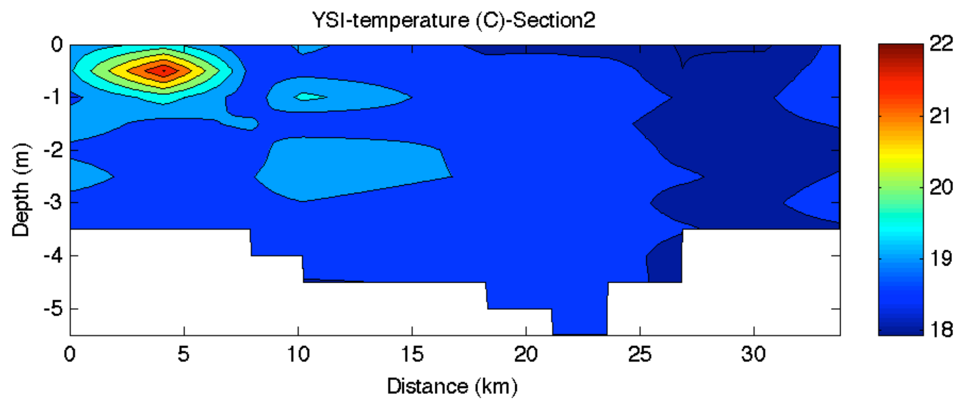

YSI-ph-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
8.1
8
7.9
7.8
7.7
7.6
7.5

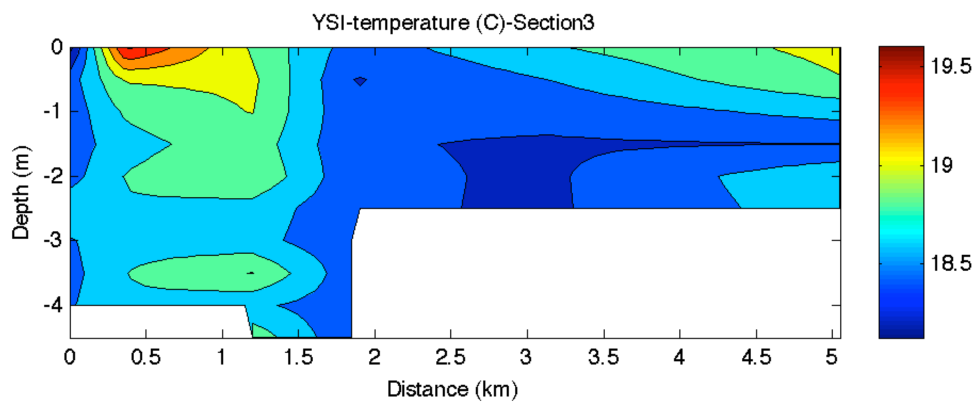

YSI-salinity (pps)-Section1
Depth (m)
0
-5
-10
-15
0
5
10
15
20
Distance (km)
35
30
25
20
15
10
5

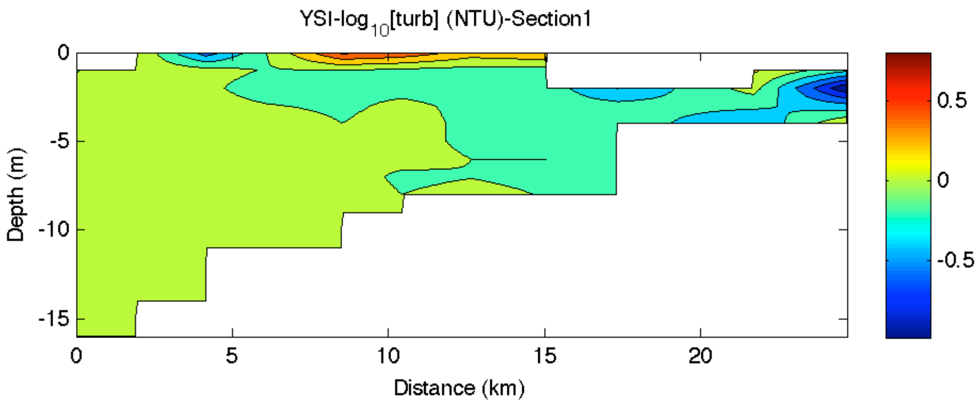

YSI-salinity (pps)-Section2
Depth (m)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
Distance (km)
30
25
20
15
10
5


YSI-salinity (pps)-Section3
Depth (m)
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Distance (km)
30
25
20
15
10
5

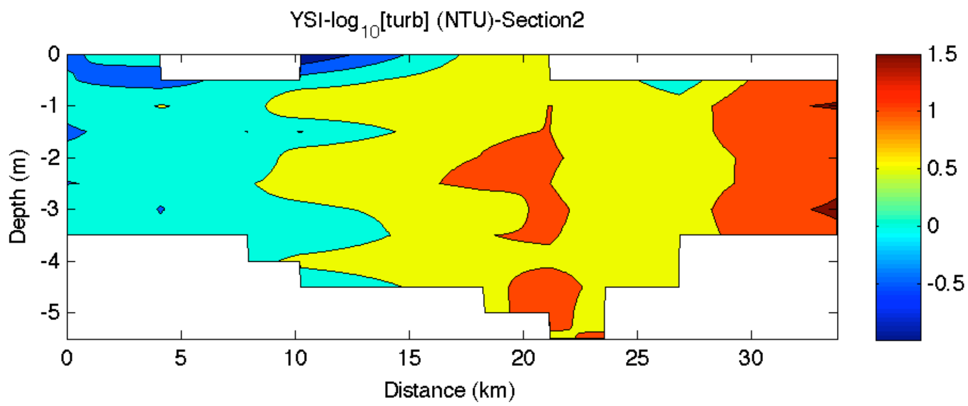

YSI-temperature (C)-Section1
Depth (m)
Distance (km)


YSI-temperature (C)-Section2
Depth (m)
Distance (km)

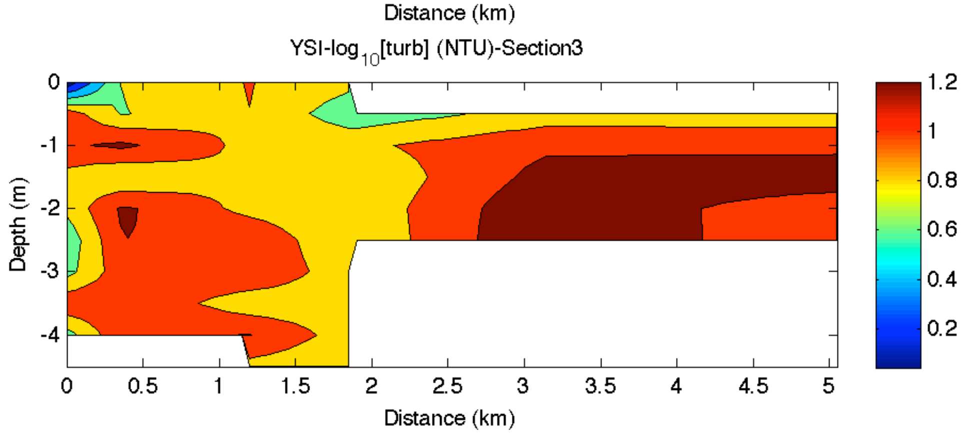

YSI-temperature (C)-Section3
Depth (m)
Distance (km)



YSI-log10[turb] (NTU)-Section1
Depth (m)
Distance (km)
0
-5
-10
-15
0
5
10
15
20
0.5
0
-0.5



YSI-log10[turb] (NTU)-Section2
Depth (m)
Distance (km)
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
1.5
1
0.5
0
-0.5



YSI-log10[turb] (NTU)-Section3
Depth (m)
Distance (km)
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1.2
1
0.8
0.6
0.4
0.2

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