Lesson 3: Salinity Cycles in an Estuary

Focus Question:
How does salinity in an Estuary change with the tide cycle?

Objective:
- To graph salinity and tidal data on a line graph
- To describe how salinity changes in relation to tide levels

S.C. Curriculum Standards:
5-2.3 Compare the characteristics of different ecosystems (including estuaries/salt marshes, oceans, lakes and ponds, forests, and grasslands).
7-5.2 Classify matter as element, compound, or mixture on the basis of its composition.
5-1.3 Construct a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables.
5-3.2 Analyze patterns and functions with words, tables, and graphs.
7-3.2 Analyze tables and graphs to describe the rate of change between and among quantities.

Purpose: A graphing and analysis activity in which students will interpret and compare graphs and tables to relate and predict salinity changes to the tide cycle.

Time Duration: 1-2 hours

Materials:
Each student group:
- Blue Marker
- Red Marker
- Tide Chart and Salinity Data for 1 24 hour period(Appendix 1)

Each student:
- Graph Paper (Appendix 2)
- Student worksheet (Appendix 3)

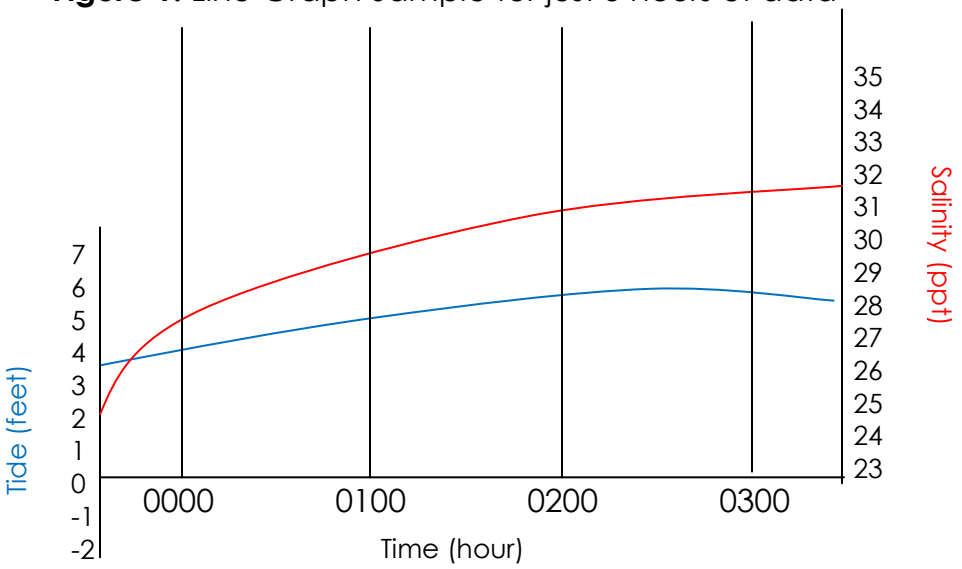
Vocabulary:
Salinity- the concentration of salt in water that is typically measured in parts per thousand (ppt) with freshwater ranging from 0-4ppt, estuarine water ranging from 10-30 ppt and open ocean salinity ranging from 32-35 ppt.

Procedures:
Hooking Students
- Show images of an ocean, lake, an estuary in random order (get from the web or postcards, etc). Have students predict the order of these bodies of water from high salinity to lowest salinity (freshwater). Check their work and ask them how they made their decisions.
- Ask the students if they think salinity is always the same or changes in an estuary. Again, ask for their reasons.

Student Engagement:
Each student will use data from a tide chart and a salinity chart to graph both on a single graph. From this graph, they can analyze the relationship between salinity and tides.

1. Distribute Tide Chart and Salinity Chart to each student. Review the following: unit of measurement for tide height; the unit of measurement for salinity; the unit of time (Appendix 4)
2. On graph paper (Appendix 2), construct a line graph with two Y axis and one X axis (See Figure 1):
    - Salinity on Right Y axis- (ppt) ranging from 23-35 ppt
    - Tide Height Left Y axis- (feet) ranging from -2 to 7 with 0 representing mean low tide
    - Time X axis- (hour)

Figure 1. Line Graph Sample for just 3 hours of data



3. Plot tide data on their line graph with the BLUE marker, label HIGH TIDE and LOW TIDE on the graph and connect the blue data points with a smooth curve line.
4. Plot salinity data with the RED marker, then connect these data points with a smooth curve line.

Student Reflection:
Using your graph, explain the relation between changing tides and salinity .

Appendix 1: Student Data Charts for Charleston, SC

Date	Time	Salinity (ppt)
7/21/09	0:00	28.42
7/21/09	0:30	27.53
7/21/09	1:00	25.51
7/21/09	1:30	26.42
7/21/09	2:00	26.16
7/21/09	2:30	25.59
7/21/09	3:00	25.31
7/21/09	3:30	19.81
7/21/09	4:00	25.66
7/21/09	4:30	24.98
7/21/09	5:00	21.84
7/21/09	5:30	29.36
7/21/09	6:00	31.04
7/21/09	6:30	31.54
7/21/09	7:00	32.14
7/21/09	7:30	32.71
7/21/09	8:00	33.42
7/21/09	8:30	33.42
7/21/09	9:00	31.02
7/21/09	9:30	29.21
7/21/09	10:00	28.77
7/21/09	10:30	28.95
7/21/09	11:00	28.3
7/21/09	11:30	27.95
7/21/09	12:00	27.68
7/21/09	12:30	27.34
7/21/09	13:00	26.76
7/21/09	13:30	25.87
7/21/09	14:00	25.56
7/21/09	14:30	25.27
7/21/09	15:00	25.21
7/21/09	15:30	25.56
7/21/09	16:00	25.6
7/21/09	16:30	26.7
7/21/09	17:00	27.32
7/21/09	17:30	29.88
7/21/09	18:00	30.35
7/21/09	18:30	31.98
7/21/09	19:00	33.61
7/21/09	19:30	34.07
7/21/09	20:00	33.08
7/21/09	20:30	32.23
7/21/09	21:00	32.96
7/21/09	21:30	33.15
7/21/09	22:00	34.65
7/21/09	22:30	32.84
7/21/09	23:00	33.48
7/21/09	23:30	32.52

DATA SET 1: Data for July 21, 2009

July 2009								
Date	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**
7/21/09	01:50	-0.2	07:42	5.2	13:50	-0.9	20:16	6.8

Data Set 2: July 22, 2009

Date Time	Salinity (ppt)
7/22/09 0:00	31.26
7/22/09 0:30	28.28
7/22/09 1:00	29.06
7/22/09 1:30	28.11
7/22/09 2:00	26.54
7/22/09 2:30	26.6
7/22/09 3:00	26.68
7/22/09 3:30	26.37
7/22/09 4:00	25.92
7/22/09 4:30	23.79
7/22/09 5:00	19.82
7/22/09 5:30	23.81
7/22/09 6:00	26.96
7/22/09 6:30	29.7
7/22/09 7:00	29.39
7/22/09 7:30	32.29
7/22/09 8:00	32.44
7/22/09 8:30	32.87
7/22/09 9:00	34.34
7/22/09 9:30	34.54
7/22/09 10:00	27.93
7/22/09 10:30	29.43
7/22/09 11:00	31.25
7/22/09 11:30	29.64
7/22/09 12:00	29.21
7/22/09 12:30	29.03
7/22/09 13:00	27.99
7/22/09 13:30	27.85
7/22/09 14:00	27.52
7/22/09 14:30	27.14
7/22/09 15:00	26.21
7/22/09 15:30	26.08
7/22/09 16:00	25.95
7/22/09 16:30	25.84
7/22/09 17:00	26.21
7/22/09 17:30	26.58
7/22/09 18:00	27.48
7/22/09 18:30	30.29
7/22/09 19:00	30.83
7/22/09 19:30	31.24
7/22/09 20:00	33.09
7/22/09 20:30	34.63
7/22/09 21:00	34.17
7/22/09 21:30	35.25
7/22/09 22:00	28.71
7/22/09 22:30	31.3
7/22/09 23:00	31.43
7/22/09 23:30	34.16

July 2009								
Date	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**
7/22/09	02:43	-0.4	08:41	5.4	14:47	-1	21:11	6.8

DATA SET 3: Data for July 23, 2009

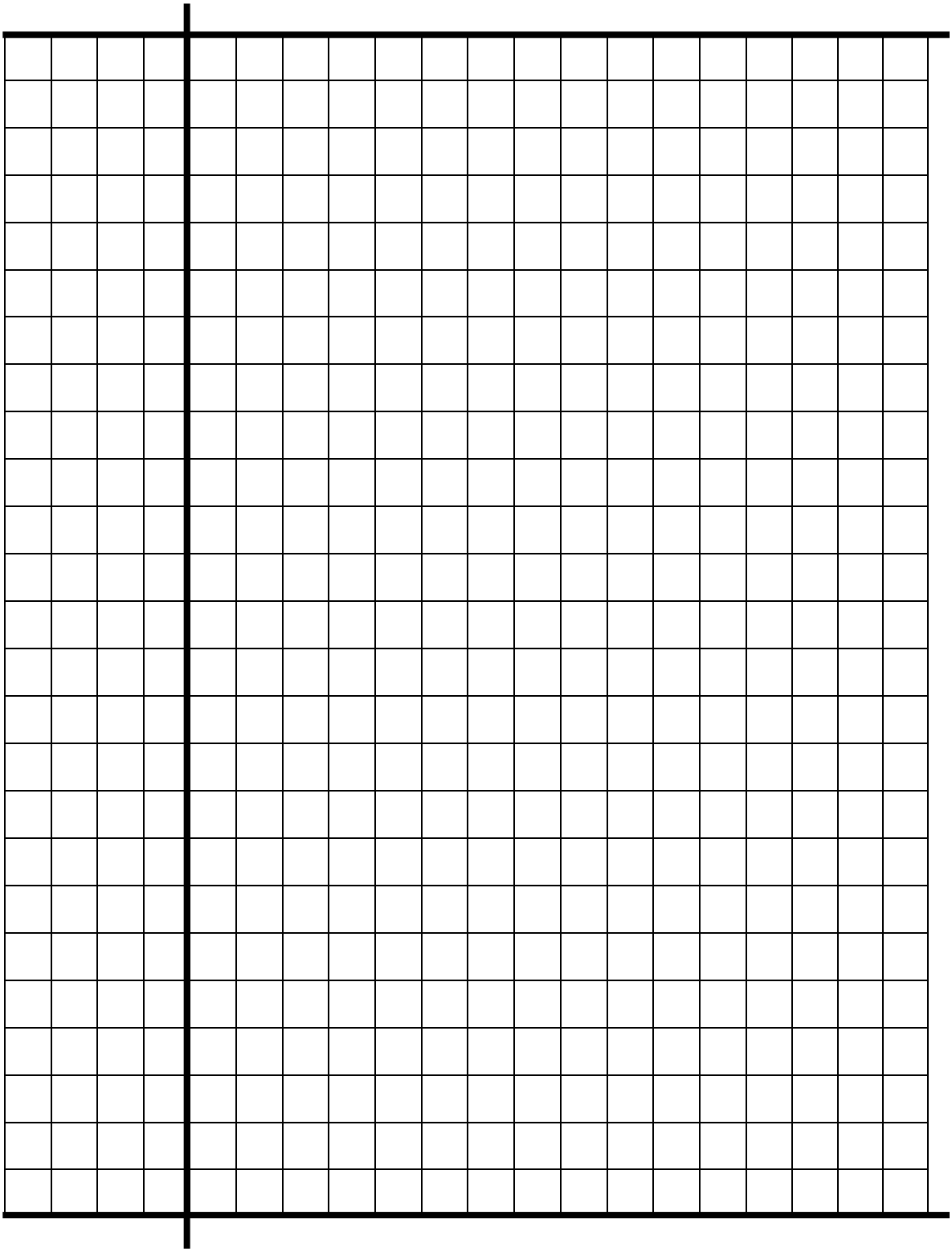
Date Time	Salinity (ppt)
7/23/09 0:00	22.98
7/23/09 0:30	30.46
7/23/09 1:00	24.83
7/23/09 1:30	27.44
7/23/09 2:00	19.67
7/23/09 2:30	25.84
7/23/09 3:00	27.73
7/23/09 3:30	27.81
7/23/09 4:00	27.35
7/23/09 4:30	26.67
7/23/09 5:00	23.36
7/23/09 5:30	25.2
7/23/09 6:00	26.48
7/23/09 6:30	25.42
7/23/09 7:00	21.03
7/23/09 7:30	25.37
7/23/09 8:00	27.16
7/23/09 8:30	32.31
7/23/09 9:00	32
7/23/09 9:30	32.73
7/23/09 10:00	24.91
7/23/09 10:30	34.05
7/23/09 11:00	33.36
7/23/09 11:30	32.27
7/23/09 12:00	29.19
7/23/09 12:30	29.1
7/23/09 13:00	29.22
7/23/09 13:30	28.85
7/23/09 14:00	27.93
7/23/09 14:30	27.77
7/23/09 15:00	24.68
7/23/09 15:30	24.08
7/23/09 16:00	27.17
7/23/09 16:30	26.66
7/23/09 17:00	25.83
7/23/09 17:30	26.3
7/23/09 18:00	26.51
7/23/09 18:30	27.55
7/23/09 19:00	26.72
7/23/09 19:30	29.82
7/23/09 20:00	31.94
7/23/09 20:30	32.75
7/23/09 21:00	27.71
7/23/09 21:30	33.78
7/23/09 22:00	33.98
7/23/09 22:30	33.13
7/23/09 23:00	33.78
7/23/09 23:30	32.25

July 2009								
Date	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**	**Time**	**Height**
7/23/09	03:34	-0.6	09:39	5.6	15:42	-0.9	22:03	6.7

Appendix 2: Graph Paper for Line Graph

Y Axis:

X Axis:



Y Axis:

Appendix 3: Student Worksheet (Teacher copy)

1. In looking at your graph, did you notice any patterns or similarities between the TIDE DATA line and the SALINITY DATA line?
   Yes, the highest salinity concentrations occurred at or around high tide.

2. When were salinity concentrations the highest? (Tide Height, Time & Date)
   At high tide on (answer will vary on time and date)

3. Why was the salinity higher at high tide?
   The water was coming into the estuary from the ocean and the ocean's salinity is around 32ppt

4. When were salinity concentrations the lowest?
   At low tide

5. Why was the salinity lower at low tide?
   Since water was rushing out to the ocean and allowing water to flow down from rivers and off the land.

6. What other events can impact salinity levels in an estuary?
   Hurricanes, rain, and drought

Focus Question: How does salinity in an Estuary change with the tide cycle?

Student Worksheet

1. In looking at your graph, did you notice any patterns or similarities between the TIDE DATA line and the SALINITY DATA line?

2. When were salinity concentrations the highest? (Tide Height, Time & Date)

3. Why was the salinity higher at high tide?

4. When were salinity concentrations the lowest?

5. Why was the salinity lower at low tide?

6. What other events can impact salinity levels in an estuary?

Focus Question: How does salinity in an Estuary change with the tide cycle?

Appendix 4: CONVERSION SHEET FOR MILITARY TIME

STANDARD	24-HOUR
12 MIDNIGHT	0000
12:01 AM	0001
12:15 AM	0015
12:30 AM	0030
12:45 AM	0045
1 AM	0100
2 AM	0200
3 AM	0300
4 AM	0400
5 AM	0500
6 AM	0600
7 AM	0700
8 AM	0800
9 AM	0900
10 AM	1000
11 AM	1100

STANDARD	24-HOUR
12 NOON	1200
12:01 PM	1201
12:15 PM	1215
12:30 PM	1230
12:45 PM	1245
1 PM	1300
2 PM	1400
3 PM	1500
4 PM	1600
5 PM	1700
6 PM	1800
7 PM	1900
8 PM	2000
9 PM	2100
10 PM	2200
11 PM	2300

Appendix 5: Background on Salinity

Salinity is the measurement of the concentration of salt in water, usually measured in parts per thousand (ppt) although chemists often measure salinity in units of micrograms per liter (mg/L). The salinity of seawater in the open ocean is remarkably constant at about 35 ppt. Freshwater ranges from 0-4 ppt and brackish water is about 5 ppt. Salinity in estuarine waters vary with the tides and may range between 5 to 30 ppt depending on how close to the inlet and ocean or how close to the river, the tidal cycle and often weather. Storms can dump rain and lower salinity or push ocean water further inland and up rivers.

In estuaries, salinity levels are generally highest near the ocean and lowest where freshwater streams and rivers enter. In addition to proximity to freshwater sources and the ocean, salinity concentrations also vary throughout the tidal cycle; as water rushes in from the ocean at 35 ppt, salt water is pushed inland and higher salt concentrations carried into the estuary as high tide occurs. Hours later the tide recedes and the river water dominates, lowering the salinity.

Some estuaries can have salinity layers. As freshwater is less dense than salt water, river water can almost "float" on top of saltier ocean water. Saltier water sinks towards the bottom. This layering occurs during the tide cycle and after periods of heavy rain or storm water runoff. The layers will remain separated due to these density differences until mixing occurs by waves and currents.

During periods of drought and less river flow, salinity levels may be higher than average in the estuary. The opposite is true during stormy or hurricane events.

Estuarine organisms have adapted to difference in salinity changes. Some fish simply swim to stay the salinity they prefer. They may stay near the bottom in the salt water layer while freshwater fish are found in the upper layers. Other animals can osmoregulate using kidneys or other organs to maintain a constant concentration of salt in their tissues and blood. Other animals, like jellyfish, have cells that can increase or decrease water and still survive.