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Maryland Sea Grant Extension Program

CRAB SHEDDERS WORKBOOK SERIES

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Using Water Quality Conversion Tables for Soft Crabbing

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INTRODUCTION

Closed system crab shedding, to be consistently successful, requires periodic monitoring and maintenance of the system's water quality. Three important parameters to monitor are dissolved oxygen, salinity and temperature. The *Water Quality Conversion Tables for Soft Crab Shedding* (UM-SG-MAP-85-01), published by Maryland Sea Grant Extension, is a selection of conversion tables for routine reference when measuring these parameters. This publication is a user's guide to these tables.

Dissolved oxygen, or oxygen concentration, refers to the amount of oxygen in solution in water. It varies inversely with temperature and salinity; thus, oxygen increases with decreasing temperature and/or salinity and decreases with increasing temperature and/or salinity. Dissolved oxygen is also consumed by aquatic organisms such as crabs and bacteria.

The amount of available oxygen in a crab shedding system will vary with time. Its concentration is affected by the number of crabs in the system, bacteria in the biological filter, algae in an algal filter, temperature changes, and the salinity of the water. Table 1, Solubility of Oxygen in Water Exposed to Water Saturated Air, gives values of oxygen solubility when oxygen in the water is at equilibrium with the atmosphere.

Salinity is defined as the amount of organic and inorganic material dissolved in water. Because of evaporation, salinity increases over time in a closed system, though these increases occur slowly. Table 2, Specific Gravity and Salinities, and Table 3, Hydrometer Reading Conversion at Any Temperature to Specific Gravity at 15°C, can be used to convert specific gravity measured at any temperature to salinity in parts per thousand.

Water temperature refers to the degree of heat in the shedding system water. While crab shedders often measure temperature in degrees Fahrenheit (°F), water quality tables are based on degrees Celsius (°C). Tables 4 and 5, Temperature Conversion Charts, allow easy conversions from °C to °F or °F to °C.

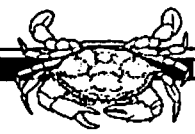


TABLE 1: Solubility of Oxygen in Water Exposed to Water Saturated Air

Purpose

To determine the concentration at saturation of oxygen at a given salinity and temperature.

The concentrations of oxygen in water will vary depending on water temperature and salinity. One hundred percent saturation exists at normal atmospheric pressures when oxygen in the water is at equilibrium with oxygen in the surrounding air, and nothing in the water is either consuming or giving off oxygen.

Typically, saturation oxygen tables are used to calibrate dissolved oxygen measurements or to report dissolved oxygen concentrations as a percentage of saturation. The tables can also be used for estimating how much oxygen should be in well-aerated water at a given temperature and salinity.

Definition of Terms

Temperature—The water temperature in degrees Celsius (°C).

Salinity—The water salinity in parts per thousand (ppt).

Oxygen Concentration—The amount of oxygen at saturation in water in parts per million (ppm).

Directions for Determining Oxygen Solubility

1. Measure water temperature in °C and locate the row corresponding to that temperature.
2. Determine the salinity in ppt and locate the column corresponding to that salinity.
3. The intersection of the temperature row and the salinity column is the saturation concentration of dissolved oxygen in parts per million, ppm. (For example, a temperature of 15°C and salinity of 10 ppt has a solubility of 9.47.)
4. For values of salinity and/or temperature falling between the table values, use the closest salinity and/or temperature.

How to Measure Dissolved Oxygen

Several methods are available for measuring dissolved oxygen; these include titration procedures, membrane electrodes and test kits. For discussion of the titration procedure refer to Standard Methods (APHA 1981) or Spotte (1979). Membrane electrodes coupled with electronic meters offer simple methods, though they may be expensive.

TABLE 1:

Solubility of Oxygen in Water Exposed to Water Saturated Air (ppm)

Temperature °C	Salinity (ppt)								
	0	5	10	15	20	25	30	35	40
0	14.60	14.11	13.64	13.18	12.74	12.31	11.90	11.50	11.11
1	14.20	13.73	13.27	12.83	12.40	11.98	11.59	11.20	10.83
2	13.81	13.37	12.91	12.49	12.07	11.67	11.29	10.91	10.55
3	13.45	13.00	12.58	12.16	11.76	11.38	11.00	10.64	10.29
4	13.09	12.67	12.25	11.85	11.47	11.09	10.73	10.38	10.04
5	12.76	12.34	11.94	11.56	11.18	10.82	10.47	10.13	9.80
6	12.44	12.04	11.65	11.27	10.91	10.56	10.22	9.89	9.57
7	12.13	11.74	11.37	11.00	10.65	10.31	9.98	9.66	9.35
8	11.83	11.46	11.09	10.74	10.40	10.07	9.75	9.44	9.14
9	11.55	11.19	10.83	10.49	10.16	9.84	9.53	9.23	8.94
10	11.28	10.93	10.58	10.25	9.93	9.62	9.32	9.03	8.75
11	11.02	10.67	10.34	10.02	9.71	9.41	9.12	8.84	8.56
12	10.77	10.43	10.11	9.80	9.50	9.21	8.92	8.65	8.38
13	10.53	10.20	9.89	9.59	9.30	9.01	8.74	8.47	8.21
14	10.29	9.98	9.68	9.38	9.10	8.82	8.56	8.30	8.04
15	10.07	9.77	9.47	9.19	8.91	8.64	8.38	8.13	7.88
16	9.86	9.56	9.28	9.00	8.73	8.47	8.21	7.97	7.73
17	9.65	9.36	9.09	8.82	8.55	8.30	8.05	7.81	7.58
18	9.45	9.17	8.90	8.64	8.39	8.14	7.90	7.66	7.44
19	9.26	8.99	8.73	8.47	8.22	7.98	7.75	7.52	7.30
20	9.08	8.81	8.56	8.31	8.07	7.83	7.60	7.38	7.17
21	8.90	8.64	8.39	8.15	7.91	7.69	7.46	7.25	7.04
22	8.73	8.48	8.23	8.00	7.77	7.55	7.33	7.12	6.91
23	8.56	8.32	8.08	7.85	7.63	7.41	7.20	6.99	6.79
24	8.40	8.16	7.93	7.71	7.49	7.28	7.07	6.87	6.68
25	8.24	8.01	7.79	7.57	7.36	7.15	6.95	6.75	6.57
26	8.09	7.87	7.65	7.44	7.23	7.03	6.83	6.64	6.46
27	7.95	7.73	7.52	7.31	7.11	6.91	6.72	6.53	6.35
28	7.81	7.59	7.39	7.18	6.98	6.79	6.61	6.42	6.25
29	7.67	7.46	7.26	7.06	6.87	6.68	6.50	6.32	6.15
30	7.54	7.34	7.14	6.94	6.76	6.57	6.39	6.22	6.05
31	7.41	7.21	7.02	6.83	6.65	6.47	6.29	6.12	5.96
32	7.29	7.09	6.90	6.72	6.54	6.36	6.19	6.03	5.87
33	7.17	6.98	6.79	6.61	6.44	6.27	6.10	5.94	5.78
34	7.05	6.86	6.68	6.51	6.34	6.17	6.01	5.85	5.69
35	6.94	6.75	6.58	6.41	6.24	6.07	5.92	5.76	5.61
36	6.82	6.65	6.47	6.31	6.14	5.98	5.83	5.68	5.53
37	6.72	6.54	6.37	6.21	6.05	5.89	5.74	5.59	5.45
38	6.61	6.44	6.27	6.12	5.96	5.81	5.66	5.51	5.37
39	6.51	6.34	6.18	6.03	5.87	5.72	5.58	5.44	5.30
40	6.41	6.25	6.09	5.94	5.79	5.64	5.50	5.36	5.22

Source: Colt, John. 1984. *Computation of Dissolved Gas Concentrations in Water as Functions of Temperature, Salinity, and Pressure.* American Fisheries Society, Bethesda, Maryland. 154 pp.

TABLE 2: Specific Gravity and Salinities

TABLE 3: Hydrometer Reading Conversions at any Temperature to Specific Gravity at 15°C

Purpose

These tables provide an accurate and inexpensive method for converting specific gravity measurements to salinity in parts per thousand (ppt).

Crabs must be kept in environments with salinities close to those they are accustomed to. Sudden changes in salinity disturb their internal water and salt concentrations and can often lead to physiological stress.

Salinity measurements are usually obtained indirectly through the measurement of an associated property of the water. Hydrometers measure specific gravity of a solution based on bouyancy; refractometers measure the refractive or light-bending properties of water, which change directly as the specific gravity changes. Specific gravity in turn is directly related to the salinity of the solution.

Tables 2 and 3 enable you to convert specific gravity measurements of closed culture systems (and natural waters) to values of salinity. With these values, salinity in a closed system can be adjusted to that of the natural water from which the crabs were taken.

Other measurements of salinity rely on electrical and chemical properties of the water. Choose a salinity-measuring device that is simple to use and cost effective. Often, a hydrometer is adequate—the procedures given below are for use with a hydrometer.

TABLE 2:

Specific Gravity and Salinities

Specific Gravity	Salinity (ppt)	Specific Gravity	Salinity (ppt)
0.9991	0.0	1.0134	18.5
0.9995	0.5	1.0137	19.0
1.0000	1.0	1.0141	19.5
1.0003	1.5	1.0145	20.0
1.0007	2.0	1.0149	20.5
1.0011	2.5	1.0153	21.0
1.0015	3.0	1.0157	21.5
1.0019	3.5	1.0160	22.0
1.0023	4.0	1.0164	22.5
1.0026	4.5	1.0168	23.0
1.0030	5.0	1.0172	23.5
1.0034	5.5	1.0176	24.0
1.0038	6.0	1.0180	24.5
1.0042	6.5	1.0183	25.0
1.0046	7.0	1.0187	25 5
1.0049	7.5	1.0191	26 0
1.0053	8.0	1.0195	26.5
1.0057	8 5	1.0199	27.0
1.0061	9.0	1.0202	27 5
1.0065	9.5	1.0206	28.0
1.0069	10.0	1.0210	28.5
1.0072	10.5	1.0214	29.0
1.0076	11.0	1.0218	29.5
1.0080	11.5	1.0222	30.0
1.0084	12.0	1.0226	30.5
1.0088	12.5	1.0229	31.0
1.0092	13.0	1.0233	31.5
1.0095	13.5	1.0237	32.0
1.0099	14.0	1 0241	32.5
1.0103	14.5	1.0245	33.0
1.0107	15.0	1.0248	33 5
1.0111	15.5	1.0252	34 0
1.0114	16.0	1.0256	34.5
1.0118	16.5	1.0260	35.0
1.0122	17.0	1.0264	35.5
1.0126	17.5	1.0268	36.0
1.0130	18.0		

American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1975. Standard Methods for The Examination of Water and Wastewater. 14th Edition. American Public Health Association, Washington, D.C., 1193 pp.

Definition of Terms

Salinity—Traditionally defined as the total amount of solid material dissolved in 1 kg of seawater when all of the carbonate has been converted to oxide, all bromine and iodine replaced by chlorine and all organic matter completely oxidized. This solid material is expressed in grams and salinity reported in parts per thousand (ppt or ‰). Salinity includes both the inorganic ions in solution and the organic compounds (Spotte 1979).

Density—Mass per unit volume of water in grams/milliliter (g/ml).

Specific Gravity—The ratio of a given volume of liquid, i.e., seawater, to an equal volume of distilled water. Specific gravity is unitless.

Temperature—The water temperature in degrees Celsius (°C).

TABLE 3:

Hydrometer Reading Conversions At Any Temperature to Specific Gravity at 15°C

Observed Hydrometer Reading	Temperature (°C) 0	5	10	15	20	25	30	35
0.9991	-3	-6	-5	0	8	18	32	47
1.0000	-4	-6	-5	0	8	19	32	47
1.0007	-4	-7	-5	0	8	19	32	48
1.0015	-5	-7	-5	0	8	19	33	48
1.0023	-5	-7	-5	0	8	19	33	48
1.0030	-6	-7	-5	0	8	19	33	48
1.0038	-6	-8	-6	0	8	20	33	49
1.0046	-6	-8	-6	0	9	20	34	49
1.0053	-6	-8	-6	0	9	20	34	49
1.0061	-7	-8	-6	0	9	20	34	50
1.0069	-8	-8	-6	0	9	20	34	50
1.0076	-8	-9	-6	0	9	20	35	50
1.0084	-8	-9	-6	0	9	20	35	50
1.0092	-9	-9	-6	0	9	21	35	51
1.0099	-9	-9	-6	0	9	21	35	51
1.0107	-10	-10	-6	0	9	21	36	51
1.0114	-10	-10	-6	0	9	21	36	51
1.0122	-10	-10	-7	0	10	21	36	52
1.0130	-11	-10	-7	0	10	22	36	52
1.0137	-11	-11	-7	0	10	22	36	52
1.0145	-12	-11	-7	0	10	22	37	53
1.0153	-12	-11	-7	0	10	22	37	53
1.0160	-12	-11	-7	0	10	22	37	53
1.0168	-12	-12	-7	0	10	22	37	53
1.0176	-13	-12	-7	0	10	23	38	54
1.0183	-13	-12	-7	0	10	23	38	54
1.0191	-14	-12	-8	0	10	23	38	54
1.0199	-14	-12	-8	0	10	23	38	54
1.0206	-14	-13	-8	0	10	23	38	55
1.0214	-14	-13	-8	0	10	23	38	55
1.0222	-15	-13	-8	0	11	23	39	55
1.0229	-15	-13	-8	0	11	24	39	55
1.0237	-16	-14	-8	0	11	24	39	55
1.0245	-16	-14	-8	0	11	24	39	56
1.0252	-16	-14	-8	0	11	24	39	56
1.0260	-17	-14	-8	0	11	24	40	56
1.0268	-17	-14	-9	0	11	24	40	56

Source: Spotte, Stephen. 1979. *Seawater Aquariums*, John Wiley & Sons, New York. 413 pp.

Directions for Measuring Salinity in ppt with a Hydrometer

1. Fill a large graduated cylinder or bucket ⅔ full with sample water. The water must be completely motionless for measuring specific gravity.

2. Measure the specific gravity with a hydrometer to 4 decimal places by reading the scale of the hydrometer at the water line as it floats. (For example, assume a reading of 1.0069.)

3. Measure the water temperature simultaneously (if reading is in °F, convert to °C; see table 5 below).

4. Find the temperature correction factor from Table 3, Hydrometer Reading Conversion at any Temperature to Specific Gravity at 15°C. Locate the correct column by the temperature corresponding to the nearest 5°C. Locate the correct row with an observed hydrometer reading closest to the measured hydrometer reading. The intersection of the temperature column and the hydrometer reading row is the correction factor. (For example, a temperature of 10°C and hydrometer reading of 1.0069 will have a correction factor of −6, or −.0006.)

5. Correct the measured hydrometer reading (for example, 1.0069) by adding or subtracting the correction factor. (Thus, 1.0069 − .0006 = 1.0063.)

6. Use the corrected hydrometer reading as specific gravity to find the salinity to the nearest 0.5 ppt in the Table 2, Specific Gravity and Salinities, by locating the specific gravity in the table closest to the corrected hydrometer reading. (1.0063 is close to 1.0065 and corresponds to 9.5 ppt.)

Note 1: These tables can also be used to convert specific gravities to salinities measured with refractometers. Refer to the instruction manual of the refractometer for details.

Note 2: The proper hydrometer must be used for measuring seawater specific gravity, i.e., in the range of 0.9990 to 1.03000 and should be readable to 4 decimal places. (The hydrometer for measuring specific gravity in a car radiator is out of the range for seawater.)

TABLE 4:
Temperature Conversion Chart (°C–°F)

°C	°F	°C	°F
0	32.0	21	69.8
1	33.8	22	71.6
2	35.6	23	73.4
3	37.4	24	75.2
4	39.2	25	77.0
5	41.0	26	78.8
6	42.8	27	80.6
7	44.6	28	82.4
8	46.4	29	84.2
9	48.2	30	86.0
10	50.0	31	87.8
11	51.8	32	89.6
12	53.6	33	91.4
13	55.4	34	93.2
14	57.2	35	95.0
15	59.0	36	96.8
16	60.8	37	98.6
17	62.6	38	100.4
18	64.4	39	102.2
19	66.2	40	104.0
20	68.0		

For temperatures outside of the range in this chart use the conversion

$$°F = \frac{9}{5} °C + 32$$

TABLE 5:
Temperature Conversion Chart (°F–°C)

°F	°C	°F	°C	°F	°C
32	0.0	55	12.8	78	25.6
33	0.6	56	13.3	79	26.1
34	1.1	57	13.9	80	26.7
35	1.7	58	14.4	81	27.2
36	2.2	59	15.0	82	27.8
37	2.8	60	15.6	83	28.3
38	3.3	61	16.1	84	28.9
39	3.9	62	16.7	85	29.4
40	4.4	63	17.2	86	30.0
41	5.0	64	17.8	87	30.6
42	5.6	65	18.3	88	31.1
43	6.1	66	18.9	89	31.7
44	6.7	67	19.4	90	32.2
45	7.2	68	20.0	91	32.8
46	7.8	69	20.6	92	33.3
47	8.3	70	21.1	93	33.9
48	8.9	71	21.7	94	34.4
49	9.4	72	22.2	95	35.0
50	10.0	73	22.8	96	35.6
51	10.6	74	23.3	97	36.1
52	11.1	75	23.9	98	36.7
53	11.7	76	24.4	99	37.2
54	12.2	77	25.0	100	37.8

For temperatures outside of the range in this chart use the conversion

$$°C = (°F - 32)\frac{5}{9}$$

TABLE 4: Temperature Conversion Chart (°C-°F)

Purpose

Table 4 is for converting temperatures measured in degrees Celsius (°C) to degrees Fahrenheit (°F).

Use of the Table

Locate the temperature in degrees Fahrenheit by the row corresponding to the nearest degree Celsius. Read across to find the value in °F. Round the conversion to the nearest whole number.

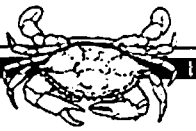
TABLE 5: Temperature Conversion Chart (°F-°C)

Purpose

Table 5 is for converting temperatures measured in degrees Fahrenheit (°F) to temperatures in degrees Celsius (°C).

Use of the Table

Locate the temperature in degrees Celsius by entering the table along the row corresponding to the temperature as measured to the nearest degree Fahrenheit. Read across to find the value of °C. Round the conversion to the nearest whole number.



EXAMPLES FOR USING THE WATER QUALITY CONVERSION TABLES

Example A: Find the temperature of water in degrees Fahrenheit that measures
1. 20°C
2. 9°C
3. 33.2°C
4. 24.6°C
5. 47°C

Solution:: For all of these conversions, use Table 4, Temperature Conversion Chart (°C—°F).
1. 20°C = 68.0°F
2. 9°C = 48.2°F or rounded, 48°F
3. 33.2°C = 33°C (rounded) = 91°F (rounded)
4. 24.6°C = 25°C (rounded) = 77°F
5. 47°C—must use formula:
   °F = ⅘°C + 32
   °F = ⅘ × 47 + 32
   °F = 85 + 32 = 117
   47°C = 117°F

Example B: Find the temperature in degrees Celsius that measures
1. 41°F
2. 68°F
3. 83.5°F
4. 28°F

Solution: For all of these conversions, use Table 5, Temperature Conversion Chart (°F—°C).
1. 41°F = 5.0°C
2. 68°F = 20.0°C
3. 83.5°F = 84°F (rounded)
   = 28.9°C = 29°C (rounded)
4. 28°F—must use formula
   °C = (°F − 32) × ⅝
   °C = (28 − 32) × ⅝
   °C = (−4) × ⅝ = ²⁰⁄₉ = −2.2
   28°F = −2°C (rounded)

Example C: Find the saturation concentration of oxygen in water.
1. 5°C and 0 ppt salinity
2. 50°F and 20 ppt salinity
3. 73°F and 27.0 ppt salinity

Solutions:
1. In Table 1, Solubility of Oxygen in Water Exposed to Water Saturated Air (ppm), enter the row at 5°C and column at 0 ppt = *12.76 ppm.*
2. First convert 50°F to 10°C (Table 5). At 10°C and 20 ppt = *9.93 ppm.*
3. 73°F = 22.8°C = 23°C. 27.0 ppt salinity is closer to 25 ppt, so enter the table at 23°C and 25 ppt = *7.41 ppm.*

Example D: Find the salinity of water with an observed hydrometer reading of 1.0070 and a temperature of 68°F.

Solution:
1. Convert temperature from °F to °C using Table 5, Temperature Conversion Chart (°F—°C). *68°F = 20°C.*
2. Find the temperature correction factor from Table 3 Hydrometer Reading Conversions at any Temperature to Specific Gravity at 15°C. At 20°C and 1.0070 observed hydrometer reading, the correction factor is *9*, or .0009.
3. Correct the observed reading: 1.0070 + .0009 = *1.0079.*
4. Find the salinity in ppt from Table 2, Specific Gravity and Salinities: 1.0079 = *11.5 ppt.*

Example E: Find the solubility of oxygen in water that is 10°C and has an observed hydrometer reading of 1.0130.

Solution:
1. Find the temperature correction factor from Table 3, Hydrometer Reading Conversions: at 10°C and 1.0130 observed hydrometer reading, the correction factor is: *−7*, or −.0007.
2. Correct the observed reading: 1.0130 − .0007 = *1.0123.*
3. Find the salinity in ppt from Table 2, Specific Gravity and Salinities: 1.0123 = *17.0 ppt.*
4. Find the solubility of oxygen from Table 1, Solubility of Oxygen in Water Exposed to Water Saturated Air (ppm): rounding 17 ppt to 20 ppt and at 10°C = *9.93 ppm.*

Note: To get a more accurate value for 17 ppt, interpolate 17 ppt between 15 ppt and 20 ppt on the table. The saturation value is then 10.09 ppm (1.6% higher than 9.93 from the rounded salinity of 20 ppt).

REFERENCES

American Public Health Association (AHPA). 1981 *Standard Methods for Examination of Water and Wastewater.* APHA, Washington. 1134 pp.

Colt, John. 1984. *Computation of Dissolved Gas Concentration in Water as Functions of Temperature, Salinity, and Pressure.* American Fisheries Society, Bethesda, Maryland. 154 pp.

Spotte, Stephen. 1979. *Seawater Aquariums.* John Wiley and Sons, New York. 413 pp.

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