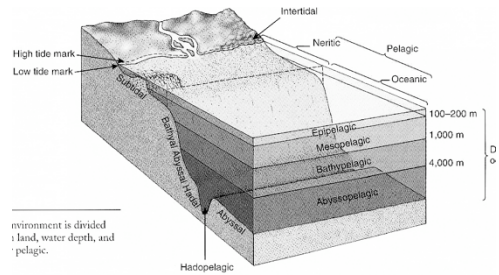


Ecology of the Water Column (Biological Oceanography)

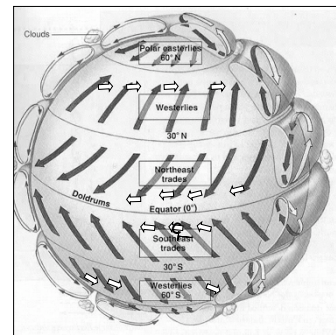
- I. Ocean Circulation
- II. Water Column Production
 - A. Coastal Oceans
 - B. Open Oceans
 - E. Micronutrients
 - F. Harmful Algal Blooms
- III. Zooplankton and Nekton

Includes the coastal zone and the pelagic zone, the realm of the oceanographer



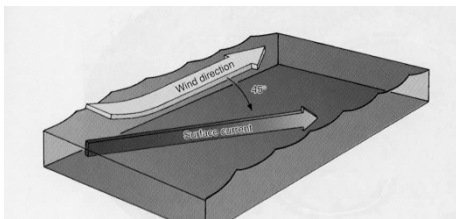
The water column is also important to benthic production over a great part of the ocean

I. Ocean Circulation

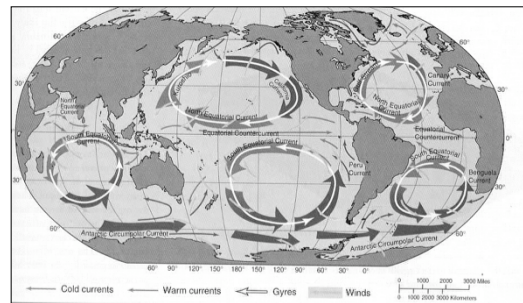


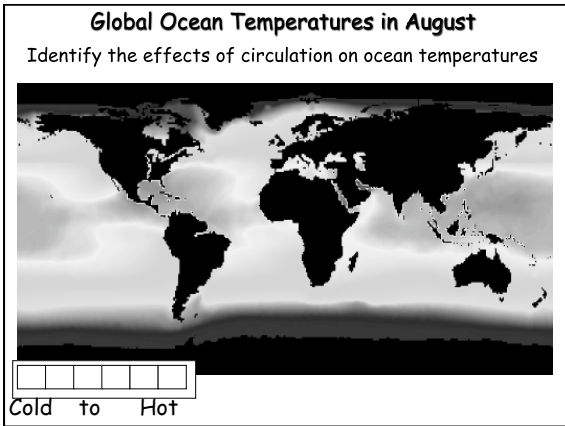
Winds and coriolis forces push waters to the right in the northern hemisphere, left in the South

Because of the Coriolis Effect, surface currents do not move parallel to the wind but at an angle of 45 deg. from wind direction



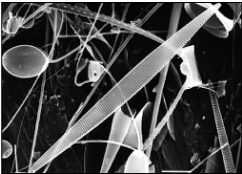
In the main ocean basins, the currents form circular systems (gyres) that dominate global circulation and climate.



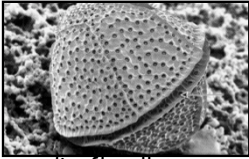


II. Water Column Primary Productivity
Who are the producers?
Geographic Patterns?
Seasonal Patterns?

What are the important primary producers in the water column?



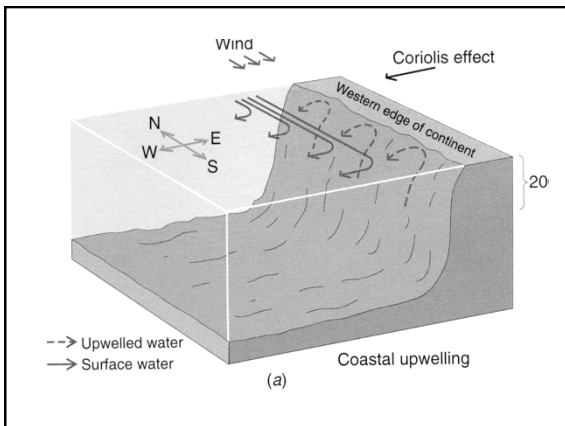
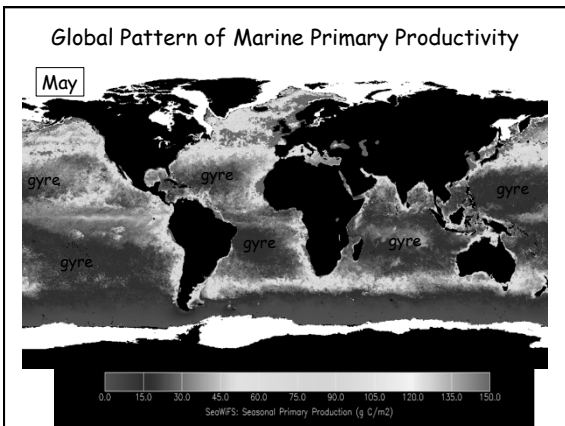
Diatoms
Cyanobacteria
Coccolithophorids
Cryptomonads

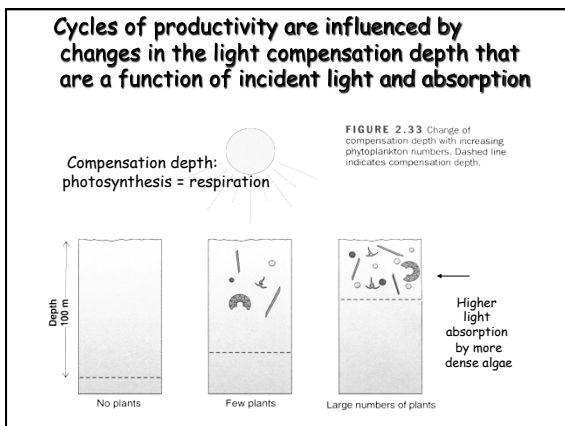
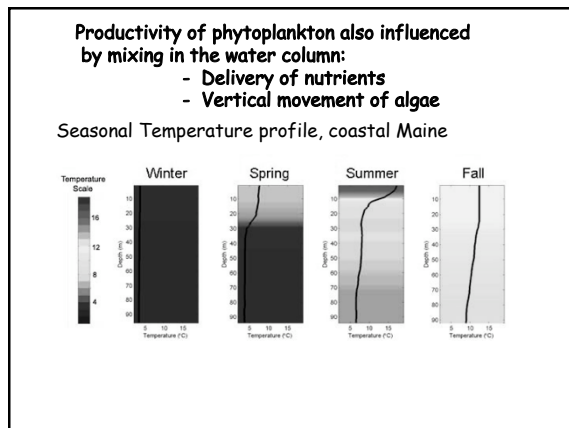
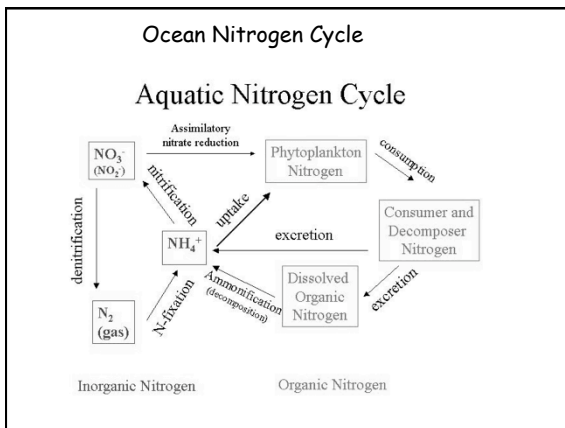
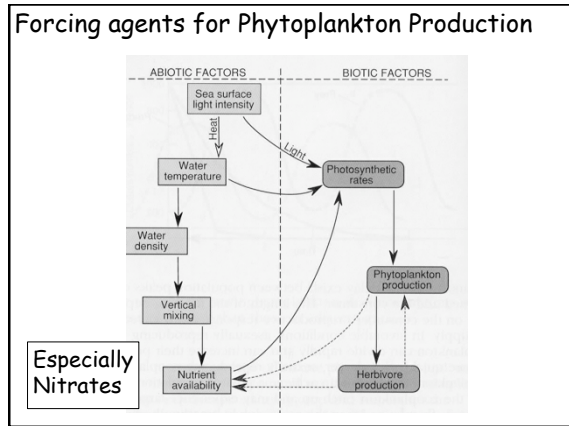
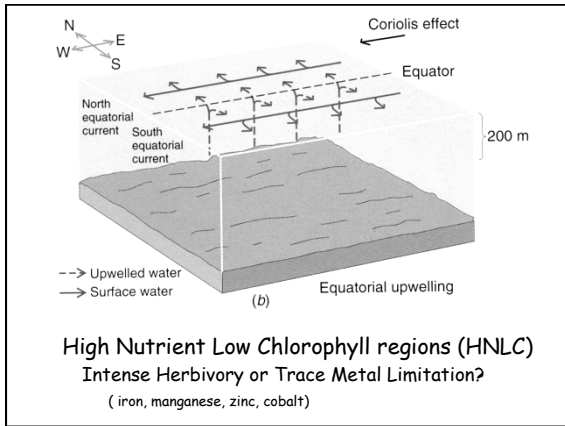


dinoflagellates
All microscopic and mostly as single cells or short chains

Production by phytoplankton is generally lower than that of bottom plants

ENVIRONMENT	RATE OF PRODUCTION (grams of carbon fixed/m ² /yr)
<i>Pelagic Environments</i>	
Arctic Ocean	0.7-1
Southern Ocean (Antarctica)	40-260
Subpolar seas	50-110
Temperate seas (oceanic)	70-180
Temperate seas (coastal)	110-220
Central ocean gyres**	4-40
Equatorial upwelling areas**	70-180
Coastal upwelling areas**	110-370
<i>Benthic Environments</i>	
Salt marshes	260-700
Mangrove forests	370-450
Seagrass beds	550-1,100
Kelp beds	640-1,800
Coral reefs	1,500-3,700
<i>Terrestrial Environments</i>	
Extreme deserts	0-4
Temperate farmlands	550-700
Tropical rain forests	460-1,600





The Compensation depth is a physiological concept:
The depth at which the rate of photosynthesis for an individual plant equals the rate of respiration by that plant.

The Critical depth is an ecological concept applied to the whole community of plants and related to vertical mixing of the water:

The Compensation depth is a physiological concept:
 The depth at which the rate of photosynthesis for an individual plant equals the rate of respiration by that plant.

The Critical depth is an ecological concept applied to the whole community of plants and related to vertical mixing of the water:

It is the depth to which the total phytoplankton biomass may be circulated and still spend sufficient time above the compensation depth to have the total production equal the total respiration for a given time period
 Thus the depth of vertical mixing is another important determinant of productivity

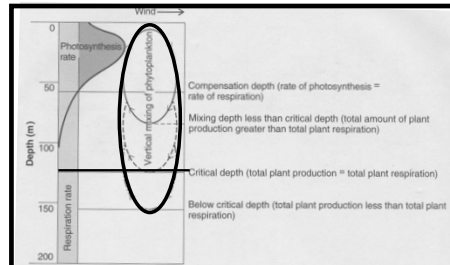
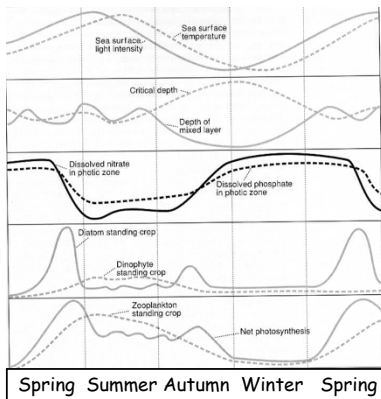
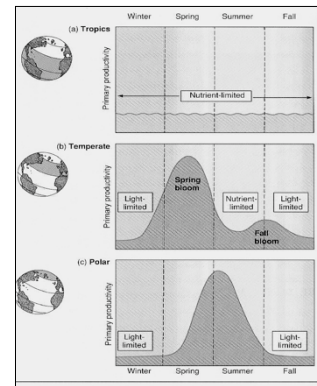


FIGURE 2.35 The relationship between the compensation depth and the critical depth. Critical depth is the depth to which the total phytoplankton biomass may be circulated and still spend enough time above the compensation depth to have a total production equal to its total respiration during the same time period. (Modified from *Productivity Of The Seas* D. H. Cushing, Oxford biology Reader, #76, 1975. Copyright 1975 Butterworth Heinemann, Reprinted by permission.)

Seasonality in the temperate zone results in two distinct peaks

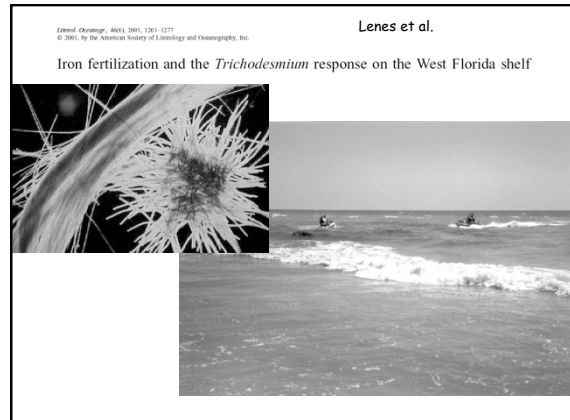


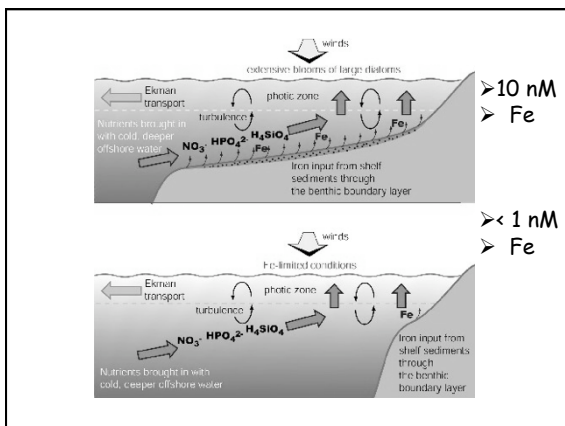
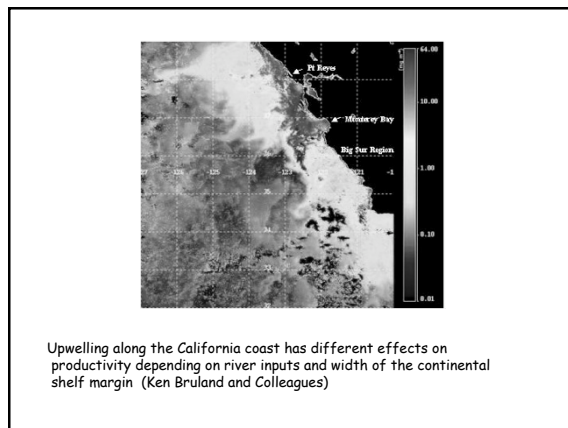
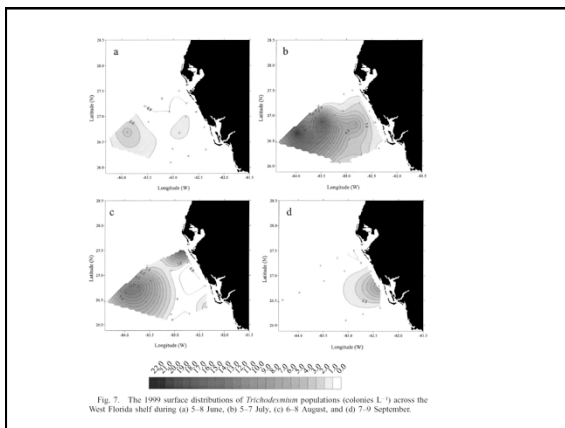
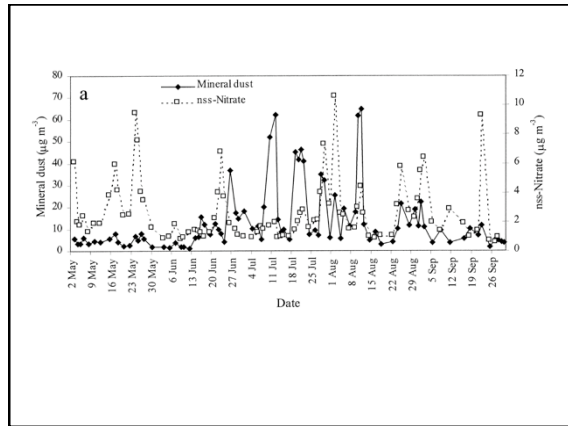
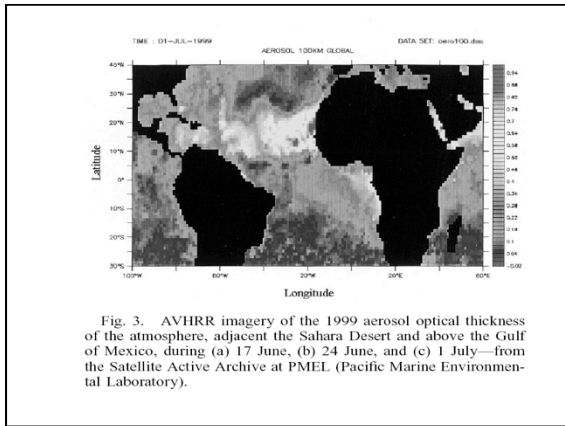
Cycles are different in other regions



Ecology of the Water Column (Biological Oceanography)

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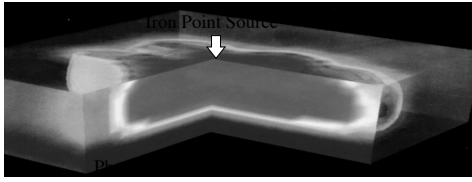
Iron Limitation of Ocean Phytoplankton

Observations

- Tropical Pacific Ocean, near the equator, rich in N and P but low in plant life.
- Light levels are plentiful
- What limits plant biomass?

Iron Experiments

- Multiple additions of dissolved iron to attain 2 nM (225 kg in 80 km²). Sulphur Hexafluoride used as tracer.
- Control is area with no iron added, only SF6 and acid solution
- Navigate ship following buoys that mark the water masses
- Measure light, chlorophyll a, nutrients, biomass, CO2 pp



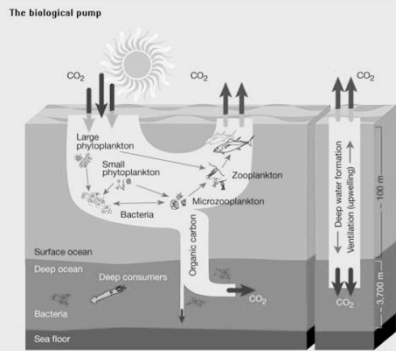
- Photosynthetic capacity: immediate and sustained increases.
- Phytoplankton Growth rate: doubled, abundance increased 20x.
- Nitrate concentrations: declined by half.
- Shift dominance to larger diatoms; release control by herbivory

Iron Ex Experiments

- Results of iron enrichment experiments taken from the US JGOFS (Joint Global Ocean Flux Study) newsletter

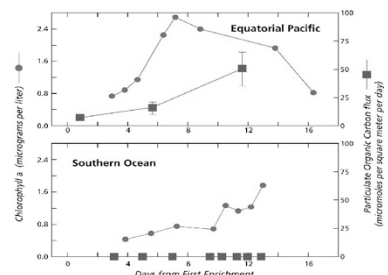
Experiment	Date	Results
IronExI	1993	3-fold increase in chlorophyll
IronExII	1996	10-fold increase in chlorophyll, 90µatm drawdown in CO ₂
SOIREE	1999	6-fold increase in chlorophyll, 25µatm drawdown in CO ₂
EisenEx	2000	4-fold increase in chlorophyll
SEEDS	2001	40-fold increase in chlorophyll
SOFEX (N)	2002	Greater than 10-fold increase in chlorophyll, Greater than 40µatm drawdown in CO ₂
SOFEX (S)	2002	Greater than 10-fold increase in chlorophyll, Greater than 40µatm drawdown in CO ₂
SERIES	2002	Greater than 10-fold increase in chlorophyll

What happens to the Carbon Produced during these Blooms?



A small proportion of organic carbon falls to the sea floor, where it may get buried under sediments and lithify.
from Nature 407, 12th October 2000

Iron Ex Experiments



This graph shows the difference in the rate of carbon assimilation and drawdown in the Equatorial Pacific and the Southern Ocean.

Mesoscale Iron Enrichment Experiments 1993-2005: Synthesis and Future Directions

P. M. Boyd¹, J. D'Amico², C. J. Lee³, B. Blain⁴, E. A. Rynin⁵, A. B. Rees⁶, M. R. Roman⁷, J. L. Sarmiento⁸, J. J. Testa⁹, M. R. Roman¹⁰, M. Roman¹¹, M. Roman¹², M. Roman¹³, M. Roman¹⁴, M. Roman¹⁵, M. Roman¹⁶, M. Roman¹⁷, M. Roman¹⁸, M. Roman¹⁹, M. Roman²⁰

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2007
Science 315
Pg. 312

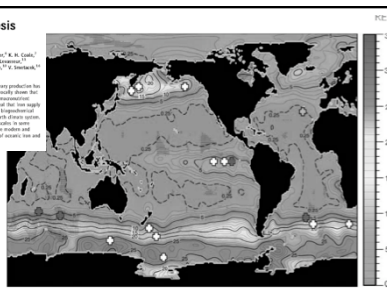


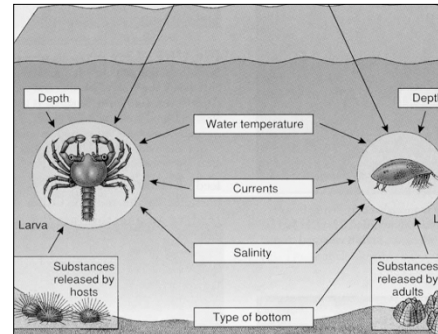
Fig. 1. Annual surface mixed layer nitrate concentrations in units of µmol l⁻¹ (µM), with approximate site locations of FAEX (white crosses), IronEx (red crosses), and a joint Fe and P enrichment study of the subtropical SCLC Atlantic Ocean (blue-green cross). SOFEX sites are SEEDS I and II (northeast Pacific), same site but symbols are off-site, SOFEX (northeast Pacific), IronEx I and II (equatorial Pacific), IronEx II is to the left, EisenEx and SOFEX (Atlantic polar waters), SOFEX is directly south of Africa, SOIREE (polar waters south of Australia), SOFEX-S (polar waters south of New Zealand), SOFEX-N (subpolar waters south of New Zealand), and SOFEX (subpolar waters nearest to New Zealand). SOFEX sites shown are the Galapagos Plume (equatorial Pacific), Antarctic Polar Front (polar Atlantic waters), and the Crozet and Kerguelen plateaus (Indian sector of Southern Ocean). Crozet is to the left of Kerguelen. For the geographical positions of the FAEX, see (6). FeEP investigated whether N-fixing phytoplankton are simultaneously limited by Fe and P; see Table 1.

Table 3. The main findings from the 12 FeEx (in chronological order from left to right) conducted between 1993 and 2005. See additional details in (6). See Table S1 to S3 for further details of initial conditions, acquisition structure, and biogeochemical response. Light climate defined as the mean irradiance available to phytoplankton in the mixed layer, not calculated according to $I = I_0 e^{-kz}$, where I_0 is mean mixed layer irradiance (PAR₀), k is the coefficient PAR₀ to the vertical light attenuation coefficient (m^{-1}), and z is the depth of the upper primary production (µmol C m⁻² d⁻¹ is the mean growth rate of the 5%–10%–15%–20%–25%–30%–35%–40%–45%–50%–55%–60%–65%–70%–75%–80%–85%–90%–95%–100%–105%–110%–115%–120%–125%–130%–135%–140%–145%–150%–155%–160%–165%–170%–175%–180%–185%–190%–195%–200%–205%–210%–215%–220%–225%–230%–235%–240%–245%–250%–255%–260%–265%–270%–275%–280%–285%–290%–295%–300%–305%–310%–315%–320%–325%–330%–335%–340%–345%–350%–355%–360%–365%–370%–375%–380%–385%–390%–395%–400%–405%–410%–415%–420%–425%–430%–435%–440%–445%–450%–455%–460%–465%–470%–475%–480%–485%–490%–495%–500%–505%–510%–515%–520%–525%–530%–535%–540%–545%–550%–555%–560%–565%–570%–575%–580%–585%–590%–595%–600%–605%–610%–615%–620%–625%–630%–635%–640%–645%–650%–655%–660%–665%–670%–675%–680%–685%–690%–695%–700%–705%–710%–715%–720%–725%–730%–735%–740%–745%–750%–755%–760%–765%–770%–775%–780%–785%–790%–795%–800%–805%–810%–815%–820%–825%–830%–835%–840%–845%–850%–855%–860%–865%–870%–875%–880%–885%–890%–895%–900%–905%–910%–915%–920%–925%–930%–935%–940%–945%–950%–955%–960%–965%–970%–975%–980%–985%–990%–995%–1000%–1005%–1010%–1015%–1020%–1025%–1030%–1035%–1040%–1045%–1050%–1055%–1060%–1065%–1070%–1075%–1080%–1085%–1090%–1095%–1100%–1105%–1110%–1115%–1120%–1125%–1130%–1135%–1140%–1145%–1150%–1155%–1160%–1165%–1170%–1175%–1180%–1185%–1190%–1195%–1200%–1205%–1210%–1215%–1220%–1225%–1230%–1235%–1240%–1245%–1250%–1255%–1260%–1265%–1270%–1275%–1280%–1285%–1290%–1295%–1300%–1305%–1310%–1315%–1320%–1325%–1330%–1335%–1340%–1345%–1350%–1355%–1360%–1365%–1370%–1375%–1380%–1385%–1390%–1395%–1400%–1405%–1410%–1415%–1420%–1425%–1430%–1435%–1440%–1445%–1450%–1455%–1460%–1465%–1470%–1475%–1480%–1485%–1490%–1495%–1500%–1505%–1510%–1515%–1520%–1525%–1530%–1535%–1540%–1545%–1550%–1555%–1560%–1565%–1570%–1575%–1580%–1585%–1590%–1595%–1600%–1605%–1610%–1615%–1620%–1625%–1630%–1635%–1640%–1645%–1650%–1655%–1660%–1665%–1670%–1675%–1680%–1685%–1690%–1695%–1700%–1705%–1710%–1715%–1720%–1725%–1730%–1735%–1740%–1745%–1750%–1755%–1760%–1765%–1770%–1775%–1780%–1785%–1790%–1795%–1800%–1805%–1810%–1815%–1820%–1825%–1830%–1835%–1840%–1845%–1850%–1855%–1860%–1865%–1870%–1875%–1880%–1885%–1890%–1895%–1900%–1905%–1910%–1915%–1920%–1925%–1930%–1935%–1940%–1945%–1950%–1955%–1960%–1965%–1970%–1975%–1980%–1985%–1990%–1995%–2000%–2005%–2010%–2015%–2020%–2025%–2030%–2035%–2040%–2045%–2050%–2055%–2060%–2065%–2070%–2075%–2080%–2085%–2090%–2095%–2100%–2105%–2110%–2115%–2120%–2125%–2130%–2135%–2140%–2145%–2150%–2155%–2160%–2165%–2170%–2175%–2180%–2185%–2190%–2195%–2200%–2205%–2210%–2215%–2220%–2225%–2230%–2235%–2240%–2245%–2250%–2255%–2260%–2265%–2270%–2275%–2280%–2285%–2290%–2295%–2300%–2305%–2310%–2315%–2320%–2325%–2330%–2335%–2340%–2345%–2350%–2355%–2360%–2365%–2370%–2375%–2380%–2385%–2390%–2395%–2400%–2405%–2410%–2415%–2420%–2425%–2430%–2435%–2440%–2445%–2450%–2455%–2460%–2465%–2470%–2475%–2480%–2485%–2490%–2495%–2500%–2505%–2510%–2515%–2520%–2525%–2530%–2535%–2540%–2545%–2550%–2555%–2560%–2565%–2570%–2575%–2580%–2585%–2590%–2595%–2600%–2605%–2610%–2615%–2620%–2625%–2630%–2635%–2640%–2645%–2650%–2655%–2660%–2665%–2670%–2675%–2680%–2685%–2690%–2695%–2700%–2705%–2710%–2715%–2720%–2725%–2730%–2735%–2740%–2745%–2750%–2755%–2760%–2765%–2770%–2775%–2780%–2785%–2790%–2795%–2800%–2805%–2810%–2815%–2820%–2825%–2830%–2835%–2840%–2845%–2850%–2855%–2860%–2865%–2870%–2875%–2880%–2885%–2890%–2895%–2900%–2905%–2910%–2915%–2920%–2925%–2930%–2935%–2940%–2945%–2950%–2955%–2960%–2965%–2970%–2975%–2980%–2985%–2990%–2995%–3000%–3005%–3010%–3015%–3020%–3025%–3030%–3035%–3040%–3045%–3050%–3055%–3060%–3065%–3070%–3075%–3080%–3085%–3090%–3095%–3100%–3105%–3110%–3115%–3120%–3125%–3130%–3135%–3140%–3145%–3150%–3155%–3160%–3165%–3170%–3175%–3180%–3185%–3190%–3195%–3200%–3205%–3210%–3215%–3220%–3225%–3230%–3235%–3240%–3245%–3250%–3255%–3260%–3265%–3270%–3275%–3280%–3285%–3290%–3295%–3300%–3305%–3310%–3315%–3320%–3325%–3330%–3335%–3340%–3345%–3350%–3355%–3360%–3365%–3370%–3375%–3380%–3385%–3390%–3395%–3400%–3405%–3410%–3415%–3420%–3425%–3430%–3435%–3440%–3445%–3450%–3455%–3460%–3465%–3470%–3475%–3480%–3485%–3490%–3495%–3500%–3505%–3510%–3515%–3520%–3525%–3530%–3535%–3540%–3545%–3550%–3555%–3560%–3565%–3570%–3575%–3580%–3585%–3590%–3595%–3600%–3605%–3610%–3615%–3620%–3625%–3630%–3635%–3640%–3645%–3650%–3655%–3660%–3665%–3670%–3675%–3680%–3685%–3690%–3695%–3700%–3705%–3710%–3715%–3720%–3725%–3730%–3735%–3740%–3745%–3750%–3755%–3760%–3765%–3770%–3775%–3780%–3785%–3790%–3795%–3800%–3805%–3810%–3815%–3820%–3825%–3830%–3835%–3840%–3845%–3850%–3855%–3860%–3865%–3870%–3875%–3880%–3885%–3890%–3895%–3900%–3905%–3910%–3915%–3920%–3925%–3930%–3935%–3940%–3945%–3950%–3955%–3960%–3965%–3970%–3975%–3980%–3985%–3990%–3995%–4000%–4005%–4010%–4015%–4020%–4025%–4030%–4035%–4040%–4045%–4050%–4055%–4060%–4065%–4070%–4075%–4080%–4085%–4090%–4095%–4100%–4105%–4110%–4115%–4120%–4125%–4130%–4135%–4140%–4145%–4150%–4155%–4160%–4165%–4170%–4175%–4180%–4185%–4190%–4195%–4200%–4205%–4210%–4215%–4220%–4225%–4230%–4235%–4240%–4245%–4250%–4255%–4260%–4265%–4270%–4275%–4280%–4285%–4290%–4295%–4300%–4305%–4310%–4315%–4320%–4325%–4330%–4335%–4340%–4345%–4350%–4355%–4360%–4365%–4370%–4375%–4380%–4385%–4390%–4395%–4400%–4405%–4410%–4415%–4420%–4425%–4430%–4435%–4440%–4445%–4450%–4455%–4460%–4465%–4470%–4475%–4480%–4485%–4490%–4495%–4500%–4505%–4510%–4515%–4520%–4525%–4530%–4535%–4540%–4545%–4550%–4555%–4560%–4565%–4570%–4575%–4580%–4585%–4590%–4595%–4600%–4605%–4610%–4615%–4620%–4625%–4630%–4635%–4640%–4645%–4650%–4655%–4660%–4665%–4670%–4675%–4680%–4685%–4690%–4695%–4700%–4705%–4710%–4715%–4720%–4725%–4730%–4735%–4740%–4745%–4750%–4755%–4760%–4765%–4770%–4775%–4780%–4785%–4790%–4795%–4800%–4805%–4810%–4815%–4820%–4825%–4830%–4835%–4840%–4845%–4850%–4855%–4860%–4865%–4870%–4875%–4880%–4885%–4890%–4895%–4900%–4905%–4910%–4915%–4920%–4925%–4930%–4935%–4940%–4945%–4950%–4955%–4960%–4965%–4970%–4975%–4980%–4985%–4990%–4995%–5000%–5005%–5010%–5015%–5020%–5025%–5030%–5035%–5040%–5045%–5050%–5055%–5060%–5065%–5070%–5075%–5080%–5085%–5090%–5095%–5100%–5105%–5110%–5115%–5120%–5125%–5130%–5135%–5140%–5145%–5150%–5155%–5160%–5165%–5170%–5175%–5180%–5185%–5190%–5195%–5200%–5205%–5210%–5215%–5220%–5225%–5230%–5235%–5240%–5245%–5250%–5255%–5260%–5265%–5270%–5275%–5280%–5285%–5290%–5295%–5300%–5305%–5310%–5315%–5320%–5325%–5330%–5335%–5340%–5345%–5350%–5355%–5360%–5365%–5370%–5375%–5380%–5385%–5390%–5395%–5400%–5405%–5410%–5415%–5420%–5425%–5430%–5435%–5440%–5445%–5450%–5455%–5460%–5465%–5470%–5475%–5480%–5485%–5490%–5495%–5500%–5505%–5510%–5515%–5520%–5525%–5530%–5535%–5540%–5545%–5550%–5555%–5560%–5565%–5570%–5575%–5580%–5585%–5590%–5595%–5600%–5605%–5610%–5615%–5620%–5625%–5630%–5635%–5640%–5645%–5650%–5655%–5660%–5665%–5670%–5675%–5680%–5685%–5690%–5695%–5700%–5705%–5710%–5715%–5720%–5725%–5730%–5735%–5740%–5745%–5750%–5755%–5760%–5765%–5770%–5775%–5780%–5785%–5790%–5795%–5800%–5805%–5810%–5815%–5820%–5825%–5830%–5835%–5840%–5845%–5850%–5855%–5860%–5865%–5870%–5875%–5880%–5885%–5890%–5895%–5900%–5905%–5910%–5915%–5920%–5925%–5930%–5935%–5940%–5945%–5950%–5955%–5960%–5965%–5970%–5975%–5980%–5985%–5990%–5995%–6000%–6005%–6010%–6015%–6020%–6025%–6030%–6035%–6040%–6045%–6050%–6055%–6060%–6065%–6070%–6075%–6080%–6085%–6090%–6095%–6100%–6105%–6110%–6115%–6120%–6125%–6130%–6135%–6140%–6145%–6150%–6155%–6160%–6165%–6170%–6175%–6180%–6185%–6190%–6195%–6200%–6205%–6210%–6215%–6220%–6225%–6230%–6235%–6240%–6245%–6250%–6255%–6260%–6265%–6270%–6275%–6280%–6285%–6290%–6295%–6300%–6305%–6310%–6315%–6320%–6325%–6330%–6335%–6340%–6345%–6350%–6355%–6360%–6365%–6370%–6375%–6380%–6385%–6390%–6395%–6400%–6405%–6410%–6415%–6420%–6425%–6430%–6435%–6440%–6445%–6450%–6455%–6460%–6465%–6470%–6475%–6480%–6485%–6490%–6495%–6500%–6505%–6510%–6515%–6520%–6525%–6530%–6535%–6540%–6545%–6550%–6555%–6560%–6565%–6570%–6575%–6580%–6585%–6590%–6595%–6600%–6605%–6610%–6615%–6620%–6625%–6630%–6635%–6640%–6645%–6650%–6655%–6660%–6665%–6670%–6675%–6680%–6685%–6690%–6695%–6700%–6705%–6710%–6715%–6720%–6725%–6730%–6735%–6740%–6745%–6750%–6755%–6760%–6765%–6770%–6775%–6780%–6785%–6790%–6795%–6800%–6805%–6810%–6815%–6820%–6825%–6830%–6835%–6840%–6845%–6850%–6855%–6860%–6865%–6870%–6875%–6880%–6885%–6890%–6895%–6900%–6905%–6910%–6915%–6920%–6925%–6930%–6935%–6940%–6945%–6950%–6955%–6960%–6965%–6970%–6975%–6980%–6985%–6990%–6995%–7000%–7005%–7010%–7015%–7020%–7025%–7030%–7035%–7040%–7045%–7050%–7055%–7060%–7065%–7070%–7075%–7080%–7085%–7090%–7095%–7100%–7105%–7110%–7115%–7120%–7125%–7130%–7135%–7140%–7145%–7150%–7155%–7160%–7165%–7170%–7175%–7180%–7185%–7190%–7195%–7200%–7205%–7210%–7215%–7220%–7225%–7230%–7235%–7240%–7245%–7250%–7255%–7260%–7265%–7270%–7275%–7280%–7285%–7290%–7295%–7300%–7305%–7310%–7315%–7320%–7325%–7330%–7335%–7340%–7345%–7350%–7355%–7360%–7365%–7370%–7375%–7380%–7385%–7390%–7395%–7400%–7405%–7410%–7415%–7420%–7425%–7430%–7435%–7440%–7445%–7450%–7455%–7460%–7465%–7470%–7475%–7480%–7485%–7490%–7495%–7500%–7505%–7510%–7515%–7520%–7525%–7530%–7535%–7540%–7545%–7550%–7555%–7560%–7565%–7570%–7575%–7580%–7585%–7590%–7595%–7600%–7605%–7610%–7615%–7620%–7625%–7630%–7635%–7640%–7645%–7650%–7655%–7660%–7665%–7670%–7675%–7680%–7685%–7690%–7695%–7700%–7705%–7710%–7715%–7720%–7725%–7730%–7735%–7740%–7745%–7750%–7755%–7760%–7765%–7770%–7775%–7780%–7785%–7790%–7795%–7800%–7805%–7810%–7815%–7820%–7825%–7830%–7835%–7840%–7845%–7850%–7855%–7860%–7865%–7870%–7875%–7880%–7885%–7890%–7895%–7900%–7905%–7910%–7915%–7920%–7925%–7930%–7935%–7940%–7945%–7950%–7955%–7960%–7965%–7970%–7975%–7980%–7985%–7990%–7995%–8000%–8005%–8010%–8015%–8020%–8025%–8030%–8035%–8040%–8045%–8050%–8055%–8060%–8065%–8070%–8075%–8080%–8085%–8090%–8095%–8100%–8105%–8110%–8115%–8120%–8125%–8130%–8135%–8140%–8145%–8150%–8155%–8160%–8165%–8170%–8175%–8180%–8185%–8190%–8195%–8200%–8205%–8210%–8215%–8220%–8225%–8230%–8235%–8240%–8245%–8250%–8255%–8260%–8265%–8270%–8275%–8280%–8285%–8290%–8295%–8300%–8305%–8310%–8315%–8320%–8325%–8330%–8335%–8340%–8345%–8350%–8355%–8360%–8365%–8370%–8375%–8380%–8385%–8390%–8395%–8400%–8405%–8410%–8415%–8420%–8425%–8430%–8435%–8440%–8445%–8450%–8455%–8460%–8465%–8470%–8475%–8480%–8485%–8490%–8495%–8500%–8505%–8510%–8515%–8520%–8525%–853

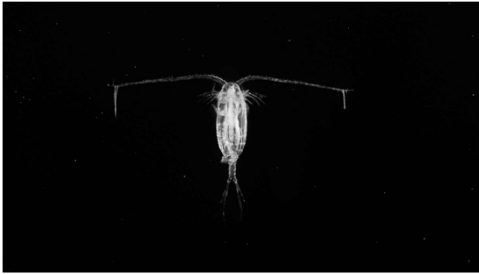
Ecology of the Water Column (Biological Oceanography)

- I. Ocean Circulation
- II. Water Column Production
 - A. Coastal Oceans
 - B. Open Oceans
 - E. Micronutrients
 - F. Harmful Algal Blooms
- III. Zooplankton and Nekton

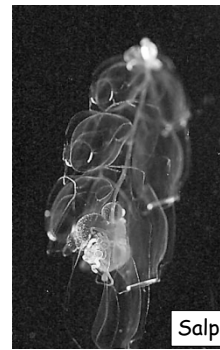
The Meroplankton are the drifting larvae of bottom-dwelling animals



The principal herbivores of phytoplankton in the ocean are the copepods which feed by creating currents, and capturing algae using a "feeding basket" made by appendages

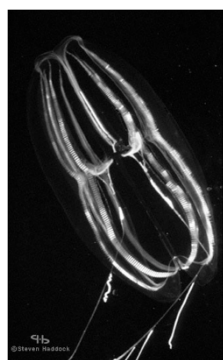


Others use filters to remove food from the water

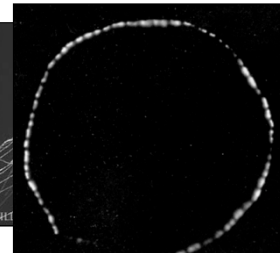
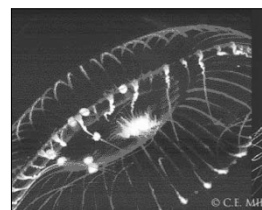


Sea butterfly

Predatory Zooplankton



Many Phytoplankton and Zooplankton are bioluminescent; they account for most of the bioluminescence in the sea



Many Phytoplankton and Zooplankton (and fish) undergo daily vertical migrations of a meter to tens of meters

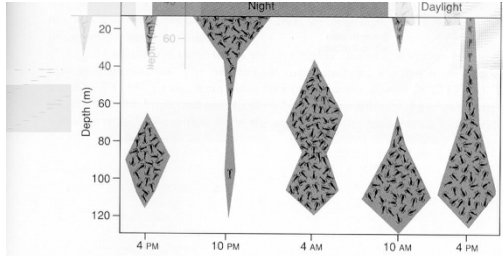
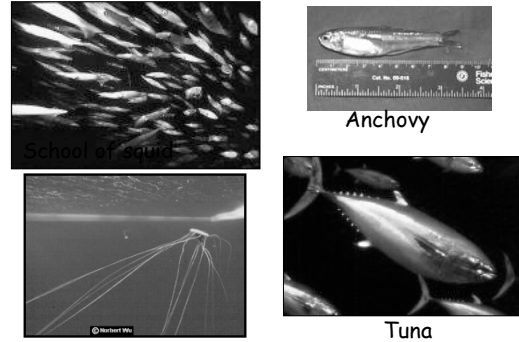
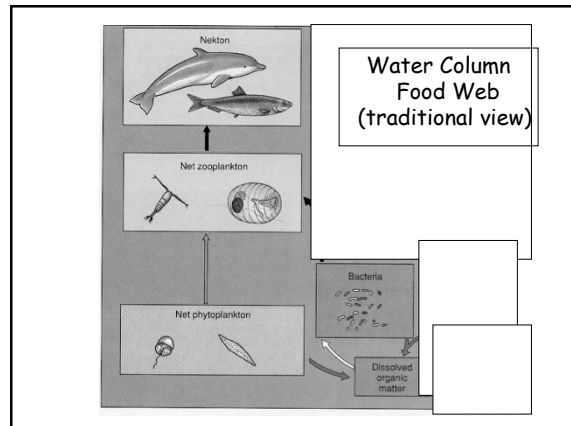
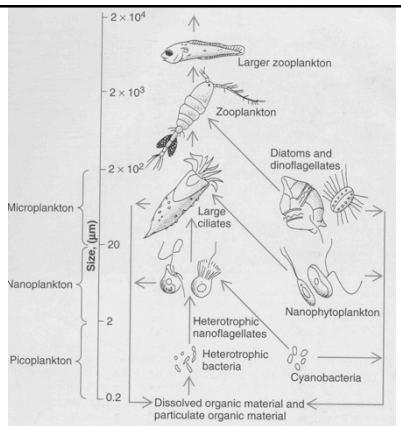


FIGURE 14.22 The depth distribution at different times of day of a vertically migrating copepod.

The nekton consists mostly of Larger, IV. The Nekton predatory type animals



V. Water Column Food Web (Simplified)



The microbial food web, an important component of water column trophic dynamics

