

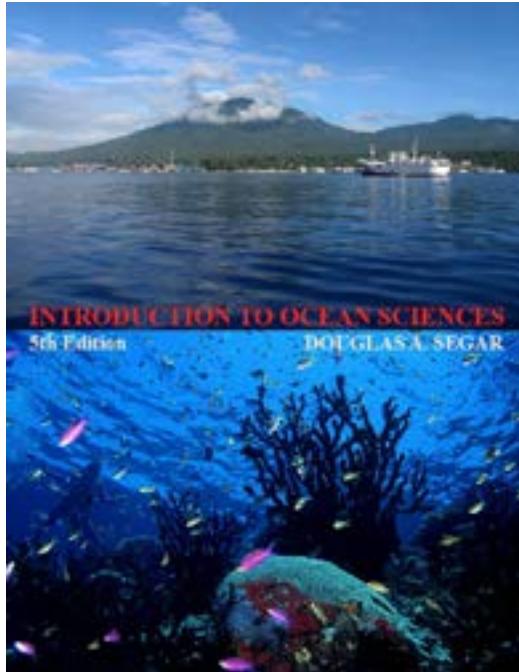
Introduction to Ocean Sciences

Fifth Edition, Third digital edition ver 5.0

DOUGLAS A. SEGAR

Contributing author Elaine Stamman Segar

© 2024 by Douglas A. Segar



This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/> or send a letter to Creative Commons, 444 Castro Street, Suite 900, Mountain View, California, 94041, USA.

What does this Creative Commons Licence mean? You are free to use the book except that you can not use the book or any part of it for any commercial purpose including personal financial gain without written permission from the author. Uses that require written permission include, but may not be limited to, sale for profit, advertising use, or use as an incentive to purchase any other product. If you transmit or transfer the book to anyone by any means, you must attribute the book by at minimum citing the author, title, and ISBN number. Also, you can not alter, transform, or build on the work.

Most images and artwork contained in the book are copyrighted to the author (or others) and you may not use any of these in any way, except in your use of the book itself, without written permission from the copyright holder.

Library of Congress Cataloging-in-Publication Data

Segar, Douglas A.

Introduction to ocean sciences / Douglas A. Segar with contributions from Elaine Stamman Segar

p. cm.

ISBN: 978-0-9857859-2-5

1.Oceanography. I. Title

INDEX

Page ranges for each chapter in the book are listed here as an aid for those who are reading from individual chapter downloads. For these readers, the easiest way to use the index may be to print just this page and use it as a reference when navigating from an index entry to the listed pages in the book.

CHAPTER 1	<i>The Ocean Planet</i>	1-14
CHAPTER 2	<i>History and Importance of Ocean Studies</i>	15-36
CHAPTER 3	<i>Studying the Oceans</i>	37-62
CHAPTER 4	<i>Plate Tectonics: Evolution of the Ocean Floor</i>	63-92
CHAPTER 5	<i>Water and Seawater</i>	93-118
CHAPTER 6	<i>Ocean Sediments</i>	119-144
CHAPTER 7	<i>Ocean-Atmosphere Interactions</i>	145-178
CHAPTER 8	<i>Ocean Circulation</i>	179-208
CHAPTER 9	<i>Ocean-Atmosphere Interactions</i>	209-234
CHAPTER 10	<i>Tides</i>	235-256
CHAPTER 11	<i>Coasts</i>	257-286
CHAPTER 12	<i>Foundations of Life in the Oceans</i>	287-322
CHAPTER 13	<i>Coastal Oceans and Estuaries</i>	323-354
CHAPTER 14	<i>Marine Ecology</i>	355-402
CHAPTER 15	<i>Ocean Ecosystems</i>	403-426
CHAPTER 16	<i>Pollution</i>	427-454
CRITICAL CONCEPTS	455-504
GLOSSARY	505-520
APPENDICES	521-533
INDEX	<i>Index 1-29</i>

Index

- absorption 59, 110-113, 117, 150, 431, 445, 471-474, 494-495
 of light in water 111
 spectrum 473
- Abudefduf sp.* (sergeant fish) 379, 388
- abyssal fan 89, 133
- abyssal hill 65, 84
- abyssal plain 65, 89, 132-133, 142-143, 303
- abyssal zone 303-304, 320, 419-420
- abyssopelagic zone 305, 320, 426
- Acanthurus pyroferus* (mimic surgeonfish) 372
- accumulation rates, of sediment 130, 133-134, 136, 142
- acid rain 103, 120, 141
- acidification 2-5, 13, 25, 128, 140-141, 264, 427, 444-447, 449, 451
- acidity, of water 3, 140, 340, 427, 447, 449, 451
- acorn barnacles 416
- acoustic 21, 29, 51-52, 59, 115-117
- acoustic current meter 51-52
- acoustic thermometry 115-116
- Acoustic Thermometry of Ocean Climate (ATOC) 115
- acoustic tomography 52
- Acreichthys tomentosus* (seagrass filefish) 366
- Acropora palmata* (elkhorn coral) 407-408
- Acropora sp.* (staghorn coral) 363
- acyclovir 27
- adaptations of fins 380
- adiabatic expansion 148-149
- Adriatic Sea 339
- adsorption 130, 294
- Aegean Sea 17
- aerobic 302, 448
- aesthetics 25, 31, 33-35
- Afghanistan 76
- Africa 14, 16-19, 66-67, 69, 76, 78, 85-86, 89, 137, 156, 163, 174, 186, 193, 201, 215, 228, 248, 302, 305, 328, 352, 475
- African Plate 67
- age
 of Earth 6
 of sediments 138
- agriculture 3, 26, 156, 281-282, 338, 436
- Agulhas Current 187, 193, 215-216
- air masses 147, 152-153, 165, 168, 172, 176
 Coriolis effect and 168, 491-492
 vertical movement of 147
- Alaska, Gulf of 163-164
- Albemarle Sound (NC) 342
- Alcatraz Island, San Francisco Bay, CA 347, 349, 438-439
- Aleutian Islands 10, 74, 198, 260, 337
- Aleutian Trench 227
- Alexandria, Egypt 17
- algae 288, 326, 356, 370, 396-397, 406, 408, 412, 414-417, 424, 430, 494-495
- benthic 326, 356, 365, 406, 430
- blooms, blooms, algal 336-337, 339, 350, 352, 429
- blue-green (cyanobacteria) 6, 289, 291, 308, 319-320, 336-337, 356, 412, 493-496
- calcareous 270, 280, 370, 406, 408, 424
- encrusting 356, 415-416, 424
- green 308, 412, 414
- Halimeda sp.* 270, 370, 396
- ice 417, 419, 424
- algal ridge 408
- alligators 318
- Allopontonia sp.* (shrimp) 370, 396
- Alpheus bellulus* (tiger pistol shrimp) 397
- Alps 76
- aluminum 65, 94, 98, 120
- Alvin submersible 21, 57, 421
- Amazon River 137, 327
- Amblygobius rainfordi* (Old Glory goby) 382
- Amblyrhynchus cristatus* (marine iguana) 317
- Amchitka Island, AK 411
- American Samoa 24
- amino acids 5, 101, 295
- ammonia 5, 33-34, 96, 104, 106, 289, 294, 476, 495
- amphidromic systems 246-248, 254-255
- amphipods 309, 391, 420, 422
- Amphiprion*
A. clarkii (Clark's anemonefish) 377
A. frenatus (tomato anemonefish) 377
A. percula (clown anemonefish) 377
A. perideraion (pink anemonefish) 363, 377
- amplitude, of waves 210, 230, 244, 252
- anadromous fishes 349-351, 384, 390-391, 398, 400, 431, 443-444, 450
- anal fins 372, 380-383
- Anchorage, AK 235, 239, 279
- anchovy 26, 160, 162, 340
- Andes Mountains 20, 73, 159, 174
- Andrew, Hurricane 170
- anemone crab (*Dardanus sp.*) 396
- anemonefishes 376-377, 385, 393
 Clark's (*Amphiprion clarkii*) 377
 clown (*Amphiprion percula*) 377
 pink (*Amphiprion perideraion*) 363, 377
 spinecheek (*Premnas biaculeatus*) 377
 tomato (*Amphiprion frenatus*) 377
- anemones 311, 359-360, 363, 368, 376-377, 385, 393, 396-397, 410-411, 416, 422
- Haddon's sea (*Stichodactyla haddoni*) 377
- rose (*Tealia lineata*) 410
- sand 360, 368
- angelfishes 372
 black-spot (*Genicanthus melanospilos*) 381
 blue-girdled (*Pomacanthus navarchus*) 381
 pearlscale (*Centropyge vrolikii*) 372
- angle of incidence 150-151, 293
- anglerfishes 381
 deep-sea (*Chaunax pictus*) 370
- Angola 302
- Anguilla sp.* (Atlantic eel) 390
- angular velocity 481, 483-484, 487-488
- animals 6, 124, 288, 290, 299, 357, 416, 418, 420, 435
- anions 97, 101
- annelid worms 367

- anoxia 128, 302, 320, 337-339, 346, 350-352, 366, 399, 423, 429-430, 435-436, 448-451
 Antarctic Bottom Water 198-199, 203, 206
 Antarctic Circumpolar Current 181, 186, 189-190
 Antarctic communities 418
 Antarctic Convergence 199, 206, 417
 Antarctic Divergence 200, 301
 Antarctic Peninsula 89, 418, 445
 Antarctica 69, 88-89, 137, 146, 153, 189, 198-200, 248, 321, 333, 445
Antennarius sp. (Lembeh frogfish) 388
Antennarius striatus (striated frogfish) 369
 Anthozoa (polypoids) 363
 anthropogenic inputs 3, 5, 128, 140, 142, 149, 201, 302, 340, 427-428, 433, 441, 443-446, 448, 451, 476, 500-503
 antinodes, of standing waves 231-233, 246, 249-252
 Antioch, CA (San Francisco Bay) 430
 aphotic zone 112, 290, 292-293, 297, 309, 356, 419-420, 425
 Appalachian Mountains 76, 88
 Aquarius 54
 Arabian Gulf, Persian Gulf 31, 130, 159
 Arabian Peninsula 163
 Arabian Sea 89, 121, 137, 302
 Arabs 18
 aragonite 127, 142
Arceichthys tomentosus (seagrass filefish) 366
 archaea 5, 53-54, 101, 125, 287-291, 293, 295-296, 299, 302-303, 305-307, 319-320, 356, 358, 392, 423-425, 494-495
 arches, sea 266
 Archimedes principle 458-459
 arcs
 island 71, 74-75, 89, 167, 421, 425
 magmatic 74-75, 84, 89-90, 260
 sedimentary 74, 89-90, 97, 260
 Arctic Ocean 28, 77, 88-89, 137, 157, 160, 164-166, 198-199, 201, 204-207, 305, 332-333, 417, 419, 421, 425-426, 441, 446, 451, 467
 Arctic Oscillation 164
Arctocephalus gazella, Antarctic fur seal 418
Arenicola brasiliensis (lugworm) 367
 Argentina 25, 174
 Argo floats 22, 56, 116
 Argo ROV 22, 56-57, 116
 Aristotle 17
 Armenia 76
 armor 368, 375-376, 399
 arrowhead crab (*Huenia heraldica*) 396
 Aruba 267, 366
 Asia 17-18, 36, 69, 71, 76, 89, 121-123, 154, 156, 159-160, 163-164, 186, 260, 318, 391
 aspect ratio 380-381
 assimilative capacity 428-432, 441, 450, 452, 501
 associations, of species 27, 288, 340, 372, 376, 392-393, 396, 400
Asthenosoma
 A. intermedium (fire urchin) 374
 A. varium (fire urchin) 396
 asthenosphere 64-65, 67, 69, 71-72, 75-77, 84, 88-91, 455, 458-461, 463
Astropyga radiata (sea urchin) 397, 407
 Atlantic eel (*Anguilla sp.*) 390
 Atlantic Ocean 18, 20, 60, 69, 77, 79, 82, 85, 88-91, 112, 115, 122-124, 127-129, 131, 133, 136-137, 157-160, 167, 171, 177, 184, 189, 192-193, 196-204, 206, 216, 240, 247-249, 263, 274, 281, 297, 299, 302, 305, 311, 349, 405, 416, 446, 470
 Atlantis 60
 atmosphere 3-5, 13, 94, 96, 101-103, 106, 123, 128, 140-141, 146-151, 160, 165, 168, 175-176, 203, 302, 412, 415-416, 444-445, 447, 462, 466-467, 471-476, 491
 convection cells in 149, 151-156, 158, 162, 175-176
 Coriolis effect in 152
 density of, 146-147
 greenhouse effect in 1, 3, 5, 14-15, 35, 58, 86-88, 91, 93, 102-103, 106, 115, 119, 138, 140, 145-146, 149-150, 164-165, 179, 199, 209, 216, 262-263, 275, 284, 321, 403, 428, 444-448, 455, 461-462, 471-477
 interactions of oceans and 58, 145
 land-ocean interactions with 153, 165, 168, 171, 173, 175-176, 326
 stratification of 146
 stratosphere of 146-147
 troposphere of, 146-147, 149, 151-153, 163, 175
 water vapor and 75, 94, 96, 103, 105-107, 139, 145-152, 167-168, 172, 174-176, 458, 462, 466-467, 473, 476, 491
 atmospheric convection 149, 151-156, 158, 162, 175-176
 atolls 20, 24, 32-33, 84-85, 89-90, 229, 233, 279-280, 282-283
 atom 95-96
 atoms 94-97, 289, 469, 495
Aurelia sp. (moon jellyfish) 310-311
 Australia 16, 19, 45, 66, 69, 89, 115, 137, 142, 156, 163, 171, 186, 280, 327, 351, 376, 445
 autonomous floats 43, 51, 57, 163, 185
 autonomous underwater vehicles (AUVs) 37-38, 47, 54, 57-59, 248
 autotrophs 288-290, 293-294, 296, 299, 305, 308, 318, 357, 412
 AUVs (autonomous underwater vehicles) 37-38, 47, 54, 57-59, 248
 avalanches 132-133, 142, 261
 Azerbaijan 76
 azidothymidine (AZT) 27
 Azores 18, 164
 back-arc basins 75, 90
 backscattering 111
 of light in water 111-112, 117, 150, 192
 of solar energy 150
 backshore 267, 269, 271, 273, 278, 282
 backwash 270-271, 274
 bacteria 97, 288-292, 295-296, 299, 302, 305-308, 420, 423, 425, 428, 494
 Baffin Bay 44, 89-90
 baguios 171
 Bahamas 123, 130, 171, 205, 443
 Baikal, Lake, Russia 426
 Baja California, Mexico 253, 328, 388, 391
Balanus glandula (barnacle) 361, 414
 baleen 299, 309-310, 315, 317, 391, 418, 497
 baleen whales 299, 309-310, 315, 317, 391, 418, 497
Balistoides conspicillum (clown triggerfish) 382
 Balkan Peninsula 76
 Baltic Sea 89-90, 159, 194, 302, 325, 338

- Banggi cardinalfish, *Pterapogon kauderni* 388
 Bangladesh 171, 281, 283
 Banzai Pipeline 225
 bar charts 7
 bar-built estuaries 342, 350
 barnacles 39, 308, 360-361, 384-385, 403, 414-416, 424, 440, 444
 acorn 385, 416
 Balanus glandula 361, 414
 buckshot 414-415
 Chthamalus sp. 361, 414
 coral (Pyrgomatidae) 361
 barracuda, chevron (*Sphyraena putnamiae*) 379
 barred filefish (*Cantherhines dumerilii*) 380
 barrier beaches 269, 275-278
 barrier islands 2, 259-260, 262, 265, 269, 274-278, 282-284, 341-342, 350
 barrier reefs 84-85, 264, 280, 282-283, 408
 bars
 baymouth 274-275
 longshore 225, 267, 269, 272-273, 275, 277, 282
 basalt 65, 77, 141
 basket star (Gorgonocephalidae) 364
 bass, striped 26, 349-350, 443
 bathyal zone 304, 320, 419
 bathymetry 39, 44, 58
 bathypelagic zone 305
 bathyscaphes 56
 bathysphere 56
 Bay of Bengal 89, 121, 137, 302, 325
 Bay of Fundy, Canada 250, 254, 259
 baymouth bars 274-275
 bays 30, 89-90, 121, 222-223, 232, 249-254, 259, 267, 281, 283, 339, 342-343, 345, 349, 429-430, 436-439, 443-444, 471
 beaches 1, 120, 209, 220, 224, 252-253, 260, 264-273, 275-279, 282-283, 304, 318, 339, 359, 388, 391, 412, 428, 432, 435-436, 440, 443, 450
 barrier 269, 275-278
 closures of 432, 436, 440
 grain size in 270-271
 human structures and 276, 282
 lagoons and 274, 282
 litter on 29, 34-35, 48, 120, 428-429, 434, 439-440, 444, 450
 longshore drift and, 33, 134, 270-271, 273-279, 282, 341-342
 seasonal changes in 273
 slope of 270, 273-274, 282
 sources of materials in, 269
 zones of 267-269, 272, 282
 Beagle, HMS 19-20, 22, 34, 85
 Beaufort Sea 259, 274
 behavior, of marine organisms 54
 Behm, Alexander 42
 Beihai, China 241
 Beijing, China 480
 bends 55, 80
 Bengal, Bay of 89, 121, 137, 302, 325
 Benguela Current 187
 Bennett's butterflyfish (*Chaetodon bennetti*) 369
 benthic environment 303-304, 318, 320, 431
 abyssal zone of 303, 320, 419
 bathyal zone of 304, 320, 419
 hadal zone of 303-304, 320, 420
 intertidal (littoral) zone of 235, 252, 268-269, 272, 282, 304, 318, 320, 356-357, 398, 403, 412, 414, 424
 sublittoral zone of 304, 320
 supralittoral zone of, also rocky intertidal communities 33, 304, 412, 415, 424
 benthic organisms 53-54, 303, 320, 356, 397
 benthos 29, 53, 299, 303-305, 311, 318, 320, 324, 350, 356, 359, 438-439, 450
 Bering Sea 3, 19, 26-28, 74, 77, 90, 137, 167, 198-199, 352, 391, 447
 Bering Strait 88, 198
 berms 267-269, 273, 282
 Bermuda 115, 130
 Bermuda Rise 130
 Big Sur, CA (near Monterey) 266
 binary fission 385
 bioaccumulation 433, 452, 500, 502
 bioassays 433, 450, 502
 bioavailable 438, 440, 450
 biochemical cycles 494, 496
 biodegradable chemicals and materials 434
 biodiversity 15, 23, 25, 355, 403, 427, 455, 499-500
 biogenous sediment 125, 134
 biogeochemical cycles 97-98, 101, 116, 119-120, 302, 307, 441, 470
 biological age dating 45, 63, 72, 93, 119, 138, 179, 455, 468-469
 biological niche 404
 biological oceanography 34, 53
 bioluminescence 306, 311, 420
 biomagnification 433, 452, 501-502
 biomass 299-300, 306, 308, 319, 330, 332, 334, 339, 349, 356, 405, 416, 423-424, 494, 496-497, 499
 biota 31, 33, 305, 329, 338, 349, 356, 420, 429, 431-433, 438-439, 441, 443, 470-471, 475
 bioturbation 138-139, 365
 black coral (*Cirrhipathes sp.*) 396, 408
 black turban snails (*Tegula funebralis*) 414
 black-headed parrotfish (*Scarus gibbus*) 375
 black-saddled mimic filefish (*Paraluteres prionurus*) 372
 black-saddled toby (*Canthigaster valentini*) 372
 black-spot angelfish (*Genicanthus melanospilos*) 381
 blooms 306, 330, 332, 334-339, 350, 388, 430, 432, 450
 algal 336-337, 339, 350, 429
 diatom 329, 335-336
 dinoflagellate 336-337, 350, 352
 blubber 318, 391
 blue-girdled angelfish (*Pomacanthus navarchus*) 381
 blue-green algae (cyanobacteria) 6, 289, 291, 308, 319-320, 336-337, 356, 412, 493-496
 blue-ringed octopus (*Haplochlaena sp.*) 287
 boiling point 78, 103-106, 147, 288, 467
 bonds
 chemical 95
 covalent 95-97, 117
 hydrogen 95-97, 103-107, 110, 116-117
 ionic 95-97, 117
 bony fishes, 312, 314, 368, 383, 399
 Bores, tidal 250, 254-255
 boron 100
 Bosnia and Herzegovina (Balkans) 76

- Boston, MA 167, 239
Bothus 312, 379
 - B. mancus* (flowery flounder) 312
 - B. sp.* (flounder) 379*Botryllus* sp. (tunicate) 363
 boundary currents, eastern 186-188, 190-191, 205-206, 328, 390
 boundary currents, western 173, 186-188, 190, 192-193, 198, 205-206, 327, 404
 box corers 44-45, 54, 59
 boxfishes 375-376
 - spotted (*Ostracion meleagris*) 375
 brackish water 366, 444
 Brahmaputra River 89, 121, 281, 325
 brain coral (*Diploria* sp.) 363
 Brazil 137, 171, 187, 221, 327
 Brazil Current 187
 breakwaters 225, 279, 282
 breezes, land and sea, 173-174, 176
 brine 31, 198-199
 British Columbia (BC), Canada 134, 137, 164
 brittle stars 393, 403, 420
 bromine 100, 104
 brown cup coral (*Paracyathus stearnsii*) 410
Bryaninops yongei (whip goby) 392
 buckshot barnacles 414-415
 budding 385
 budget
 - heat 149-150, 175
 - water 148-150
 buffering
 - of heat 106, 157, 165
 - of pH 103
 bulkheads 432
 buoyancy 116, 293, 314, 320, 356-357, 359, 379, 384, 398-400, 420, 458
 burrfishes 376
 burrowing sponge (*Oceanapia sagittaria*), 388
 butterflyfishes 368, 370, 380, 385, 393
 - Bennett's (*Chaetodon bennetti*) 369
 - Klein's (*Chaetodon kleinii*) 378
 - Meyer's (*Chaetodon meyeri*) 379
 buttress zone 408, 424
 bycatch 27
 byssal threads 415
 cables, undersea 133
 calcareous organisms 125, 137, 140
 calcite 127, 142
 calcium 3, 13, 98-100, 103, 125, 127-128, 130, 134-135, 139-140, 142-143, 269, 303, 310, 312, 316, 376, 406, 422, 425, 451
 calcium carbonate 3, 99, 103, 125, 127-128, 130, 134-135, 139-140, 142-143, 269, 303, 310, 312, 316, 376, 406, 451
 California (CA) 26, 73, 164, 174, 271, 316, 319, 328, 361, 391, 410, 414
 California Current 187, 191, 447
 California gray whale, *Eschrichtius robustus* 317, 391
 California mussel (*Mytilus californianus*) 316, 361, 389, 414
 California, Gulf of 179
 calorie (cal) 104, 106, 117
 Camille, Hurricane 170
 camouflage, in hunting and defense 368, 370, 372, 396, 399-400
 Canada 26, 45-46, 73, 88-89, 123, 134, 164-165, 174, 199, 240-241, 257, 259, 262-263, 281, 337, 342, 447
 Canary Current 187
 Canary Islands 18, 124
 Cannery Row, Monterey, CA 26
Cantherhines dumerilii (barred filefish) 380
Canthigaster valentini (black-saddled toby) 372
 canyons, submarine 43, 88, 124, 133, 260, 271, 282
 Cape Cod, MA 259, 324
 Cape Hatteras, NC 191-192, 324
 Cape Mendocino 73
 capillary waves 212-213, 216-217, 232
Carangoides sp. (trevally) 379, 381
Caranx melampygus (bluefin trevally) 372
 carbon dioxide 3-5, 14, 101-103, 116, 127-128, 130, 140, 203, 289-291, 293, 302, 427, 444-445, 447, 449, 451, 474, 494, 496
 carbon monoxide 103
 carbon organic, ; also organic matter 293, 302-303, 320-321, 339
 carbonate compensation depth (CCD) 127-128, 135-137, 139, 142, 207, 303
 carcasses 419-420, 423, 425
Carcharhinus amblyrhynchos (gray reef shark) 313, 381
Carcharodon carcharias (great white shark) 313
 carcinogens 418, 433, 450, 501, 503
 Cardiidae (cockles) 359
 cardinalfish
 - Banggi cardinalfish, *Pterapogon kauderni* 388
 - Weed (*Foa brachygramma*) 396
 Caribbean Sea 23, 89, 131, 145, 241, 249, 264, 308, 366, 408, 477
 Carmel, CA (near Monterey) 257
 carnivores 290-291, 299, 305, 308, 313, 319, 340, 356, 358-359, 385, 388, 415-416
 carotenoids 494-495
 cartilaginous fishes 314, 320
Cassiopeia andromeda (upside-down jellyfish) 310
 cassiterite 31
 catadromous fishes, 349, 351, 384, 400, 431
 Catarina, Hurricane, 171
 cations 97, 117
 caudal fins 380-381, 383, 396, 399
Caulerpa racemosa (grapeweed) 326
 caves, sea 266
 Cayman Islands 89, 145, 264
 CCD (carbonate compensation depth) 127-128, 135-137, 139, 142, 207, 303
 Celebes sweetlips (*Plectorhinchus celebicus*) 372
 celerity 210, 218, 222
 cell division 307-308
 Central America 159, 163
 central rift valleys 77, 80
 centripetal force 236-238, 254-255, 481, 483-490
Centropyge vrolikii (pearlscale angelfish) 372
 cephalopods 314, 316
 cercaria 393
 cesium 100
 cetaceans 315-316, 398
 CFCs (chlorofluorocarbons) 147
Chaetodon
 - bennetti* (Bennett's butterflyfish) 369

- C. kleinii* (Klein's butterflyfish) 378
C. meyeri (Meyer's butterflyfish) 379
Challenger, HMS 15, 20-21, 34
Chang (Yangtze) River 121
chaos, chaotic systems 1, 15, 27, 63, 67, 145, 163-165, 168, 175, 179, 201, 281, 323, 341, 455, 475, 477-480
charts, maps, mapping 7, 9, 12-14, 19, 40, 43, 168
Chaunax pictus (deep-sea anglerfish) 370
cheeklined wrasse (*Oxycheilinus digramma*) 379
Cheilinus fasciatus (redbreasted Maori wrasse) 381
chelation 330
Chelonia mydas (green sea turtle) 317, 366
chemical bonds 95
chemical oceanography 100
chemical sensing, in marine organisms 388, 398, 421
chemosynthesis 22, 289-290, 304-305, 318, 357, 421, 493, 496
chemotaxis 384
Chernobyl, Ukraine 441-443
Chesapeake Bay, VA 5, 142, 251-252, 339, 342-343, 429, 436
chevron barracuda (*Sphyraena putnamiae*) 379
Chicxulub, Mexico 140-142, 229
Chikyu 45
Chile 163, 174, 229, 263
China 24-25, 27, 31, 34, 76, 90, 121-122, 141, 250
Chiso Chemical Corporation 437
chitons 414-415
 lined (*Tonicella lineata*) 414
chlorine 13, 95, 98-100, 104, 147
chlorofluorocarbons (CFCs) 147
chlorophylls 54, 58, 112, 165, 289, 296, 300-301, 327-328, 331, 493-496
chloroplasts 493-496
chordates 311
Christmas tree worm (*Spirobranchus giganteus*) 364
chromatophores 370, 372
chronometers 10, 17-18
Chthamalus sp. (barnacle) 361, 414
Chukchi Sea 391
circulation
 deep-ocean 180, 194, 205-207, 230, 445-446
 eddies in 33, 51, 58, 179, 192-193, 198-200, 206, 235, 307, 326, 329, 331-332, 350, 405, 417, 423
 Ekman spiral 181-182, 205, 207
 Ekman transport 182-191, 194, 205-207, 269, 327-329, 345, 350, 440
 estuarine 342-343, 345-346, 348-349, 351, 436, 439, 450
 Langmuir 194-195, 206, 307, 326, 331, 345
 see also currents 77, 152, 179-180, 184, 194, 200-201, 206-207, 302, 329, 331-332, 342-343, 345-346, 349, 351, 421, 445, 463
 thermohaline 180, 194, 205-207, 230, 445-446
Cirrhipathes sp. (black coral) 396, 408
Cirrhitichthys falco (Falco hawkfish) 369
clams
 giant (*Tridacna gigas*) 397
 Tellina sp. 366
Clark's anemonefish (*Amphiprion clarkii*) 377
Clavelina sp. (lightbulb tunicate) 363
clays 120, 123, 127, 136-137, 142, 229, 465
 deep-sea (red) 136-137
Clean Water Act 432
cleaner wrasse (*Labroides phthirophagus*) 372
climate
 deep-ocean circulation and 200, 206
 interannual variations of 2, 160, 164, 175
 ocean surface currents and 173, 186-193, 198, 205-206, 327-328, 390, 404
 zones of 165-168, 175
climate change 449
 climatic winds 18, 151-154, 156-157, 160, 165, 167-168, 173, 175, 181, 185-186, 192, 283, 325, 329
 cycles of 86
 MOC and 193, 200-201, 206, 230, 235, 339, 446
 sedimentary (stratigraphic) record of 137, 139, 142
 susceptibility of ecosystems to 417
 wave heights and 216
clingfish, crinoid (*Discotrema crinophila*) 396
clinker 120
clones 385
clouds 18, 40, 145, 147, 149-150, 152, 158, 163, 166, 170, 174-176, 180, 367, 385, 422, 446, 474
clown anemonefish (*Amphiprion percula*) 377
clown triggerfish (*Balistoides conspicillum*) 382
Clypeaster (sand dollars) 407
cnidarians 311, 378
cnidocysts 311
coastal modification and, fronts in 216-217
coastal plains 85, 90, 121, 260, 263, 275, 281, 340-342, 347, 446
Coastal Zone Color Scanner 112, 192
coastal zones 2, 50, 112, 160, 192, 257, 318, 323, 326, 328, 339-340, 430, 432, 438-439, 443, 451
 characteristics of 324, 350
 currents and 187, 190-191, 206-207, 324, 326-329, 350
 food webs in 329
 human structures and 276, 282
 nutrients in 327, 331, 350
 salinity in 324
 seasonal variation in 332, 350-351
 temperature in 325
 turbidity of 326
 upwelling in 126, 160-161, 173-174, 190, 206, 294, 299-300, 327-331, 334, 339, 349-351
 waves and 179, 209, 267, 326, 331
coastline 88, 123, 187
coasts
 barrier islands on, 2, 259-260, 262, 265, 269, 274-278, 282-284, 341-342, 350
 beaches on, beaches 22, 25, 30, 32-33, 73, 85-86, 88-89, 121, 134, 136-137, 166, 170, 173-174, 181, 188, 190-191, 206, 225, 229, 240, 248, 257, 260-267, 269-271, 274-277, 279-280, 282, 302, 321, 327-328, 337, 341-342, 350, 405, 412, 416, 431-432, 446, 450, 458, 460-462
 classification depositional or erosional 257, 282
 classification primary or secondary 260
 deltas on 5, 134, 263, 281-283, 342, 429-430
 formation of 260
 human structures and 276, 282
 lagoons on 31, 84-86, 134, 233, 260, 274-276, 280, 282, 318, 323-325, 342, 391, 406-407, 424
 modification of 264

- reefs and atolls on 20, 24, 32-33, 84-85, 89-90, 225, 229, 233, 264, 279-280, 282-283, 408
 sea-level change and, 86, 88, 90-91, 135, 235, 260-262, 282, 461-462
 subduction zones near 73
 wetlands on, 2, 30, 35, 132, 134, 267, 280-283, 342, 348-349, 351, 366, 429-432, 443-444, 446, 450-451
- cobalt 31, 100, 128-129, 293-294
- coccolithophores 125-126, 306, 308, 320
- cockles (Cardiidae) 359
- Cocos Plate 73
- cod, Atlantic (*Gadus morrhua*) 312
- cohesive 131, 464-465
- Coleman's shrimp (*Periclimenes colemani*) 396
- collisions, of continents 75-76, 83, 90
- colloidal matter 130
- colonial organisms 310-311, 358, 363-364, 378, 385, 399
- Colorado (CO) 284
- Columbia River, WA 165
- Columbus, Christopher 17-18, 35-36
- common mussel (*Mytilus edulis*), 389
- common reef squid (*Sepioteuthis lessoniana*) 314, 388
- communication, in marine organisms 397, 400
- communities
- Antarctic 418
 - Arctic 419
 - at hydrothermal vents 422
 - chemosynthetic 5-6, 13, 288-291, 293, 299, 320, 356, 422-426, 494
 - marine 2, 12, 31, 56, 82-83, 264, 284, 291-292, 298, 307-308, 326, 334-335, 340, 349, 376, 404-405, 409-412, 416-417, 421-425, 431, 435, 440, 450, 499-500
 - rocky intertidal 412, 424-425
 - compensation depth 127-128, 137, 142, 207, 292-293, 303, 305, 319
 - complex systems 59, 480
 - complexed ions 440-441, 502
 - computer modeling 1, 15, 37, 50, 58-59, 145, 163-164, 179, 194, 201, 204, 287, 455, 475-476
 - computer tomography 67
 - concealment 368, 372, 374, 376, 399
 - condensation 103, 148-149, 152, 467
 - conduction 67, 77, 109, 117, 150-151, 458, 462, 466, 476, 479
 - cone shell (*Conus geographicus*) 375
 - Congo River 89
 - congregations, spawning 385
 - conservative properties, of seawater 203, 206
 - constituents, dissolved, in seawater 49, 99, 107, 116, 203
 - contaminants 31, 39, 48, 101, 103, 117, 120, 324, 342, 346, 357, 428-430, 432-434, 436-439, 444, 449-450, 453, 470-471, 476, 502
 - contamination 35, 47-48, 59, 101, 350, 418, 428, 430-432, 437, 439, 444, 450, 452-453, 471, 503
 - fat-soluble 418, 437-438
 - in dredged material 450
 - nonpoint sources 436
 - vs. pollution 428
 - continental collisions 75-76, 83, 90
 - continental crust 64-65, 69, 71, 73-76, 79, 81, 85, 88, 90-91, 458-462
 - continental drift also plate tectonics 20, 22, 45, 69
 - continental margins 71, 85-86, 88, 97, 121, 134-135, 142
 - continental rises 65, 143
 - continental shelves 22-24, 28-30, 65, 85-86, 88-90, 134-135, 142-143, 188, 190, 198, 229-230, 262, 304-305, 320, 323, 327, 331, 338-339, 405
 - continental slopes 28-29, 35, 65, 88, 130-133, 137, 141-143, 200, 423, 439
 - contour plots 7-8, 13-14
 - contours 7-8, 13-14, 168, 176, 182-183, 205, 247, 425, 491-492
 - Conus geographicus* (cone shell) 375
 - convection 67, 179, 195
 - convection cells 128, 152, 179, 194, 464
 - convergent plate boundaries 71, 73-75, 80-81, 84, 90-91, 129, 260
 - continental 75-76, 83, 90
 - oceanic 89 - conversion tables 12
 - conveyor belt circulation 200-201, 302
 - Cook Inlet 19, 28, 250
 - Cook Strait, New Zealand 19
 - Cook, James 18
 - cooperation, in hunting and defense 23, 368, 378, 399, 502
 - Copenhagen, Denmark 99
 - copepods 299, 309, 320, 358, 392, 416, 420
 - copper 31, 60, 100-101, 128-129, 139, 281, 336, 410, 422, 428, 431, 434, 440-441, 502
 - Copper River, AK 281
 - copper rockfish (*Sebastes caurinus*) 410
 - coral crabs (Cancer sp.) 374
 - coral reefs 27, 31, 84-85, 264, 280, 282-283, 326, 333, 360-361, 403-406, 424-425, 500
 - coral shrimp (*Dasykaris zanzibarica*) 370
 - coral shrimp (*Vir philippinensis*) 396
 - corals
 - black (*Cirrhipathes* sp.) 396, 408
 - brain (*Diploria* sp.) 363
 - brown cup (*Paracyathus stearnsii*) 410
 - Dendronephthya* sp. (soft coral) 363, 396, 403
 - elkhorn (*Acropora palmata*) 407-408
 - hard 326, 333, 361, 363-364, 388, 397, 403, 407, 500
 - reef building (hermatypic) 334, 404-405, 408
 - soft, 361, 363, 370, 372, 396, 403, 408, 424
 - staghorn (*Acropora* sp.) 363
 - symbiosis in 279-280, 282, 326, 333-334, 350, 396-397, 404-405, 408, 423-424, 446
 - Tubastrea* sp. 363
 - whip 370, 392, 396
 - Xenia* sp. (soft coral) 363 - core, Earth's 44-45, 64, 66-67, 81, 131, 193, 462
 - corers 44-45, 47, 54, 59
 - Coriolis effect
 - climatic winds and 152
 - Critical Concept 481
 - in estuaries 342-343, 345-346, 348-349, 351, 436, 439, 450
 - oceanic currents and 181-182, 205, 207
 - tides and 246
 - waves and 212, 230, 232 - weather systems and 1-2, 58, 145, 149, 151-152, 161, 164, 166, 168-173, 176-177, 216, 227, 232, 276, 283-284, 301, 467, 475, 477

- cormorant, double-crested (*Phalacrocorax auritus*) 318-319
 cornetfish (*Fistularia commersonii*) 378
 Corpus Christi, TX C (south of Galveston) 276
 corrosion, as factor in ocean studies 39, 48
 cosmogenous sediment 120, 131, 134, 142
 countershading 372
 covalent bonds 95-97, 117
 cowries 365, 396
 allied (*Primovula sp.*) 365
 egg (*Pseudosimnia sp.*) 396
 Crabeater seal, Lobodon carcinophagus 418
 crabs 370, 372, 376, 396, 416
 anemone (Dardanus sp.) 397
 arrowhead (*Huenia heraldica*) 396
 coral (Cancer sp.) 374
 decorator 370, 372, 396
Dorippe frascone 397
 hermit 396-397, 414, 416
 horseshoe (*Limulus polyphemus*) 252, 388-389
 king 3, 26, 311
 Majidae (Majid crabs, Family) 370
 northern kelp (*Pugettia producta*) 410
Pagurus sp. 414
 porcelain (*Porcellanella triloba*) 396
 spider (*Xenocarcinus sp.*) 370, 396
 spider (*Xenocarcinus tuberculatus*) 370, 396
Crassostrea virginica (eastern oyster) 385, 443
 crests
 of oceanic ridges 81
 of waves 210-212, 216, 219, 222-227, 232, 246, 271-272
 Crete 17, 72
 crinoid clingfish (*Discotrema crinophila*) 396
 crinoid cuttlefish 314
 crinoid shrimp (*Periclimenes amboinensis*) 370
 crinoids 314, 370, 372, 396-397, 403
 Croatia (Balkans) 76, 339
 crocodiles 318
 cross-sectional profiles 8
 crust
 continental 64-65, 69, 71, 73-76, 79, 81, 85, 88, 90-91, 458-462
 density of 63
 formation of 63
 oceanic 64-65, 67, 69, 71-77, 80-81, 84-86, 89-91, 127, 134, 138, 280, 290, 458-461
 crustaceans 116, 299, 309, 311, 317, 320, 336, 356-358, 360, 376, 381, 391-392, 416, 420-421
 crusts, phosphorite 30-31, 47, 128, 130, 142
Cryptocentrus cinctus (yellow shrimp goby) 397
 CTD samplers 49, 99
 ctenophores 310-311, 320, 358-359
Cucumaria sp. (creeping sea cucumber) 364
 cum sole motion 168, 181-183, 205, 246-247, 481, 488, 491
 currents
 Aguilhas 187, 193, 215-216
 Antarctic Circumpolar 181, 186, 189-190
 Benguela 187
 Brazil 187
 California 187, 191, 447
 Canary 187
 climate affected by 200, 206
 coastal 187, 190-191, 206-207, 324, 326-329, 350, 432
 Davidson 191
 deep-ocean 180, 194, 205-207, 230, 445-446
 East Australian 187
 ebb 235, 249, 254
 eddies in 51, 58, 179, 192-193, 206, 235, 307, 326, 329, 331, 350, 405, 417, 423
 Equatorial 186, 189-190, 205-206
 flood 235, 249
 Florida 184
 generation of 180
 geostrophic 183-189, 194, 205, 207, 492
 Gulf Stream 19, 33, 157, 167, 173, 184, 187, 189-193, 199, 201, 206-207, 230, 349, 390-391, 466
 gyre 186, 207
 horizontal pressure gradients in 184-185
 inertial 194, 206
 Kuroshio (Japan) 157, 167, 187, 193, 349
 latitudinal heat transfer by 151
 longshore 187
 measuring 49-50, 52
 open-ocean 185
 Peru 187
 residual 345, 347, 349
 restoring forces in, 180
 rip 2, 226, 232-233, 272
 soundings affected by 40
 steering forces in, 180
 subpolar (high-latitude) 189
 surface (wind-driven) 179-182, 184-185, 194, 205-207, 230, 323
 surface slope and 184-185
 tidal 33, 194, 200, 206, 235, 248-255, 326, 332, 342-343, 345-346, 348-349, 351, 423, 439
 tidal currents 33, 194, 200, 206, 235, 248-255, 326, 332, 342-343, 345-346, 348-349, 351, 423, 439
 turbidity 35, 124, 132-133, 137, 141-142, 213, 260-261, 420, 464, 466
 wave heights and 215
 cuttlefish 314, 316, 355, 370, 388
 broadclub (*Sepia latimanus*) 314
 crinoid 314
 flamboyant (*Metasepia pfefferi*) 355, 388
Cyanea sp. (jellyfish) 311
 cyanobacteria (blue-green algae) 6, 289, 291, 308, 319-320, 336-337, 356, 412, 493-496
 cycles
 biogeochemical 97-98, 101, 116-117, 119-120, 128, 296, 302, 307, 434, 441, 470
 diurnal 239-244, 246, 248-249, 254-255, 298, 309
 hydrologic 94, 441
Cyclichthys orbicularis (orbicular burrfish) 375
 cyclones
 extratropical 152, 166, 168, 171-173, 176, 227, 301
 cyclones, also hurricanes 152, 166, 168, 171-173, 176, 227, 301
 cyclonic storms 171-172
 Cymothoidae (fish doctor, isopod) 392
 cysts 288, 331
 damselfishes, lemon (*Pomacentrus moluccensis*) 392

- Dardanus* sp. (anemone crab) 397
 Dark Ages 17-18, 35
 darkspotted moray eel (*Gymnothorax fimbriatus*) 382
 dartfish (Nemateleotris magnifica) 369
 Darwin, Charles 20, 22, 34, 36, 73, 85
Dasykaris zanzibarica (coral shrimp) 370
 dating (age estimation) 138
 dating, by radioactivity 138
 Davidson current 191
 DDT 101, 429, 431, 433-434, 438, 441, 450, 452
 Dead Sea 130
 dead zones 5, 290, 302, 337-339, 350, 429, 436, 448-449, 451
 decay, radioactive 67, 204, 462, 468-469
 declination, lunar 242-245, 254
 decomposers 127, 288, 290-292, 295-299, 303, 308, 319, 321, 334, 350, 356-357, 364-366, 405, 411, 415-416, 429, 434-435, 445
 decomposition 324
 decorator crabs 370, 372, 396
 Deep Sea Drilling Program (DSDP) 22, 45
 deep-sea anglerfish (*Chaunax pictus*) 368, 370, 384
 deep-sea mud 136-137
 deep-water wave 213, 217-218, 220, 222, 232-233
 Deepwater Horizon 338, 434-435
 deforestation 13, 120
 Delaware 259, 342
 Delaware Bay 342
 deltas, river 5, 121, 134, 260, 263, 281-284, 341-342, 429-430
Dendrochirus zebra (zebra lionfish) 382
 Denmark 99
 density
 absolute 211, 456
 atmospheric 147
 of Earth's crust 64
 of lithospheric plates 65
 of marine organisms 420
 relative 109, 456, 468
 stratification by 183, 445, 456
 water 37, 49, 93, 99, 106-109, 116, 119, 145, 179, 183-184, 190, 194-195, 197, 205-206, 211, 297, 323, 455, 457-458, 462, 467-468
 deoxygenation 2-5, 13, 25, 140-141, 302, 427, 436, 444-447, 449, 451
 deposit feeders 365-367, 399-400, 406, 420, 424
 deposition
 glacial 122
 of sediment 88-89, 123, 125-126, 128, 130, 133-134, 136-139, 142, 365, 406, 431
 depth of no motion, in waves 184-185, 218
Diadema savignyi (long-spined sea urchin) 365
 diagenesis 139, 143
 diarrhetic shellfish poisoning (DSP) 336-337
 diatom ooze 134
 diatoms 125-126, 136-137, 142, 288, 296, 307-308, 320, 330, 335-337, 339, 350, 352, 376, 404
Didemnum molle (tunicate) 363
 diffusion 139, 147, 200, 295, 357-358, 366, 456-457, 476
 dikes 77
 dinoflagellates 279, 288, 293, 306, 308-309, 320, 333, 335-337, 339, 350, 352, 376, 404
 dip angle 82-83
Diploastrea heliopora (hard coral) 333
Diploria sp. (brain coral) 363
Discotrema crinophila (crinoid clingfish) 396
 dispersion 213, 219-221, 232, 423
 of waves 213, 220-221, 232
 dissipation, of waves 216
 dissolution 120, 125-127, 136, 142, 266-267
 diurnal cycles
 in temperature 165, 173
 of tides 239-243, 249, 254
 of zooplankton 297
 divergence 71, 76-77, 79, 152-153, 156-158, 166, 180-182, 184-186, 189-190, 195, 198, 200, 206, 301, 307, 462-464
 in atmospheric convection cells 152
 divergent plate boundaries 71, 76-77, 79, 82, 84, 90-91, 260
 diversity 499
 ecosystem 25, 499-500
 genetic 27, 384-385, 391, 399, 499-500
 physiological 499-500
 species 15, 27, 31, 355, 403, 426-427, 431, 455, 499-500
 DNA 22, 54, 288, 433, 503
 doldrums (intertropical convergence zone) 152, 180, 189
 dolphins, bottlenose 337
 domoic acid 336-337
 Doppler shift 52
Dorippe frascone (crab) 397
 dorsal fins 369, 372, 380-381, 383
 Dover, England 125-126
 downwelling 67, 76, 90, 152-153, 156-157, 159, 175-176, 184-185, 189-190, 194, 205-207, 298, 301, 332, 417, 462-464
 drag 40, 50, 67, 110, 378-381, 399
 Drebbel, Cornelius 56
 dredges 20, 25, 46-47, 54, 59, 278
 dredging, pollution from 29, 34-35, 349, 434, 438-439, 444, 450
 drift nets 27, 53, 318
 drifters 50, 59
 drilling 22, 28-29, 31, 35, 45, 59, 66, 72, 131, 138, 143, 230, 452
 drogues 50, 59
 drowned river valleys 341-342, 350
 drugs 25, 27, 29, 34-36, 376, 428
 dynamic height 184-185
 Earth
 age of 6
 structure of 63, 91
 uniqueness of 94
 Earth sciences 163
 earthquakes 43, 69, 80, 132-133, 141, 209, 227-229, 260, 281
 epicenters of 132, 281
 turbidity currents and 35, 124, 132-133, 137, 141-142, 213, 260-261, 420, 464, 466
 East African Rift Zone 71, 76
 East Australian current 187
 East China Sea 121
 East Pacific Rise 71, 77-78, 89, 143
 East Wind Drift 189, 205
 Easter Island 18, 71, 82
 eastern boundary currents 186-188, 190-191, 205-206, 328, 390
 eastern oyster (*Crassostrea virginica*) 385, 443
 ebb currents 235, 249, 254

- Echeneis naucrates* (remora) 313, 382
Echinocardium sp. (heart urchin) 367
 echinoderms 270, 447
 echo sounders 41-44, 59, 309
 echo sounders, wide area 43
 echolocation 398, 400
 ecological requirements, of species 355, 398
 ecology 164, 254-255, 355, 443, 445, 450
 adaptation in 294, 307, 355, 358, 365, 376, 378-384, 398-399, 416, 419-420, 500
 communication in 397, 400
 feeding in 299, 313, 334, 357-360, 363-367, 391, 398-400, 406, 415-416, 420, 422-425
 marine 355
 species associations in 340, 392, 400
 ecosystem, terrestrial 165, 291, 357, 368, 433
 ecosystems
 assimilative capacity of 428-432, 441, 450, 452, 501
 diversity in 15, 27, 31, 355, 403, 426-427, 431, 455, 499-500
 ecosystems, marine
 aphotic zone as 112, 290, 292-293, 297, 309, 356, 419-420, 425
 classification by 287, 404, 424
 communities in 404, 424
 coral reefs as 1-3, 19, 26-27, 31, 54, 63, 84-86, 126, 135, 225, 233, 259-260, 264, 279-280, 282-283, 296, 305, 318, 320, 326, 333-334, 350, 356, 360-361, 363, 372, 392, 400, 403-407, 409, 411, 424-426, 444, 446, 449, 451, 460, 500
 hydrothermal vents as, 5, 21, 31, 54, 56, 97, 101, 108, 117, 128-130, 137, 142-143, 203, 288, 290, 293, 299, 304-305, 318, 356-357, 398, 421-423, 425-426
 kelp forests as, 291-292, 306, 318, 323, 326, 356, 409-412, 416, 424-426
 nutrient-limited 294, 299, 321, 330, 332-334
 polar regions as 4, 12, 96, 102, 106, 109, 147, 150-151, 175-176, 185, 189, 198, 204, 320, 332, 351, 400, 417-419, 424, 445, 447, 466-467
 rocky intertidal communities as 304, 318, 403, 412-416, 424-425
 Sargasso Sea as 192-193, 301, 307-308, 349, 390-391, 416-417, 424-425
 Ecuador 23
 eddies 33, 51, 58, 179, 192-193, 198-200, 206, 235, 307, 326, 329, 331-332, 350, 405, 417, 423
 eels, freshwater 349
 Atlantic (*Anguilla* sp.) 390
 eels, moray 382-384
 darkspotted (*Gymnothorax fimbriatus*) 382
 EEZs (exclusive economic zones) 23-25
 effluents 103, 342, 349, 425, 429-431, 436-438, 450, 502
 egg cowrie (*Pseudosimnia* sp.) 396
 egg laying 318, 331, 385, 388-390, 399
 eggs 252-253, 311, 314, 318, 331, 384-385, 388-391, 393, 396, 399, 423
 mortality of 346, 388-389, 391, 399, 446, 449
 pelagic 252, 335, 349, 379, 384-385, 388-391, 399-400, 444
 Egyptians, ancient 17, 72, 176, 281
 Ekman motion 181, 205
 Ekman spiral 181-182, 205, 207
 Ekman transport 182-191, 194, 205-207, 269, 327-329, 345, 350, 440
 El Niño/Southern Oscillation (ENSO) 26, 153, 160-164, 175, 189-190, 230, 301, 446
Elagatis bipinnulata (trevally) 372
 electrical charge 94
 electrical conductivity 49, 57, 99, 116-117
 electrical fields 398, 400
 electrical, electrical conductivity 39, 48-49, 51, 57, 59, 99, 116-117
 electromagnetic radiation, spectrum of, also light 38, 58-59, 94, 110-111, 113, 117, 472-473
 electrons 94-96, 103-104, 120, 180, 289, 495-496
 electrostatic charge or attraction 95, 97, 132, 465
 elephant seal (*Mirounga angustirostris*) 27, 316-317, 433
 elkhorn coral (*Acropora palmata*) 407-408
 embryos 433, 502-503
 emission spectrum 473
 Emperor Seamount chain 81-83, 85
 emperor shrimp (*Periclimenes imperator*) 396
 encrust, encrustation, encrusting organisms 326, 356, 363, 365, 385, 405-406, 408, 411-412, 415-416, 424
 endangered 25, 31, 34-35
 endangered species 25, 31, 34-35
 energy
 as oceanic resource, 31, 389
 from tides 35, 253, 255
 kinetic 180, 182, 205, 211-212, 223
 of waves 32-33, 58, 131, 141, 210-214, 216-217, 219, 221-225, 228-230, 232, 254, 259, 264, 266-267, 271-273, 277, 279, 282-283, 406-408
 potential, 183, 185, 211-212, 223
 solar 123, 150-151, 166, 173, 175, 405, 466, 471-472, 474
 English Channel 249
Enhydra lutris (sea otter) 318, 411-412, 424
 ENSO (El Niño/Southern Oscillation) 26, 153, 160-164, 175, 189-190, 230, 301, 446
 environment
 benthic 303-305, 318, 320-321, 358, 431
 pelagic 303-305, 318, 320-321, 356
 enzymes 288, 295, 423
 Ephesus, Turkey 340-341
 epicenters, of earthquakes 132, 281
 epifauna 304, 356, 367, 370, 398-399
 epipelagic zone 305, 320
Epitonium billeeanum (snail) 388
 equator 135, 151, 242, 245, 301, 328, 487, 489
 Equatorial Countercurrent 207
 Equatorial Undercurrent 207
 equatorial zone, currents in 186, 189-190, 205-206
 equinoxes 150-151, 153
 Eratosthenes 17, 36
Eretmochelys imbricata (hawksbill sea turtle) 317-318
 erosion 84, 88, 120, 122-123, 257, 260, 264-271, 273, 275-279, 281-282
 by extratropical cyclones 152, 166, 168, 171-173, 176, 227, 301
 by glaciers 122
 by rivers 120
 by waves, 25, 88, 123, 172, 225, 265-267, 277-278, 282
 human activity and 281, 444
 in coastal formation and modification 88, 257, 260, 264, 267,

- 277-278, 282
 lithogenous sediment and 88, 120, 122-123, 225
 estuaries 121, 250-251, 255, 323, 341-343, 345-351, 429-432, 435-436, 438-439, 443-444, 450-451, 471
 as marine habitats 349
 bar-built, 342, 350
 circulation in 342-343, 345-346, 348-349, 351, 436, 439, 450
 coastal-plain 341-342
 contaminants in 346
 Coriolis effect in 342-343, 345-346, 348-349, 351, 436, 439, 450
 fjords as 88, 122, 132, 259, 262-263, 290, 302, 325, 332, 338, 341-343, 345-346, 351
 geological origins of 341
 partially mixed 198, 343, 345-349, 351-352, 457
 pollution in 30, 346, 471
 salinity in 342-343, 345-346, 348-349, 351, 436, 439, 450
 salt wedge 343, 345-348, 351
 sediment transport in 346
 tectonic 341-342, 350
 tidal currents in 250-251
 well-mixed 343, 345, 347-348, 351
 wetlands and 349
 eukaryotes (eukarya) 288, 292, 299, 307, 493, 495
 euphausiids 309, 320, 357-358
 Eurasian Plate 67, 90
 Europe 18-19, 82, 85, 89, 137, 163-164, 167, 175, 186, 189, 201, 206-207, 248, 279, 390, 438, 466, 475
 Europe and Asia 69, 76, 89-90, 176
 Europeans voyages of discovery by 15, 19-22, 34-35, 39, 45, 85, 423
 eustasy 63, 86, 88, 90-91, 119, 257, 261-263, 455, 458, 460-461
 eutrophication 295, 338, 430, 436, 450
 evaporation 468
 evaporites 86, 128, 130, 142
 Everest, Mount 38, 67, 82
 evolution, theory of 20, 288
 excretion 117, 383, 433
 excurrent openings 311, 358, 363, 367
 exotic terranes 73-74, 89, 97
 expansion, adiabatic 148-149
 exponential (scientific) notation 2
 extinctions, threats of 1-5, 13, 140-141, 143, 302, 318, 412, 427, 443, 445, 449, 451, 480, 499-500
 extratropical cyclones 152, 166, 168, 171-173, 176, 227, 301
 Exxon Valdez 434
 Falco hawkfish (*Cirrhitichthys falco*) 369
 Falkland Islands 25
 false cleaner wrasse 372
 fan worms 364, 368, 376
 fans, abyssal 89, 133
 farmers 477
 farming 27, 474
 fathom 40
 faults, transform 73, 79-81, 85, 90-91, 260, 342
 fauna 305, 321, 338, 365, 399, 412-413, 422-423
 fecal pellets 124, 126, 132, 291, 295, 297-298, 303, 319, 330, 350, 367
 feedback 5, 140, 419, 444, 472, 474-475
 feeding 357, 365
 deposit 365-367, 399-400, 406, 420, 424
 filter 357-358, 391, 399, 416, 422-423, 425
 grazers 297, 300, 307, 317-318, 330, 336, 357, 364-366, 399, 411-412, 415-416, 424, 430
 suspension 357-360, 363-364, 398-400, 406, 415, 420
 Ferrel cells 152-153, 156, 158-159, 166, 175, 185
 Fessender, Reginald 41
 fetch, of winds 32, 168, 214, 221, 232, 333
 Fiji 264, 313, 317, 363, 374-375, 378-379, 382, 408
 filefish 366, 372, 380
 barred (*Cantherhines dumerilii*) 380
 black-saddle mimic (*Paralutereres prionurus*) 372
 seagrass (*Acreichthys tomentosus*) 366
 filter feeders 357-358, 391, 399, 416, 422-423, 425
 fins 31, 51, 57, 310, 316, 369, 372, 376, 380-384, 396, 399, 420
 adaptations of 380
 aspect ratio of 380-381
 fire goby (*Nemateleotris magnifica*) 369
 fire urchin 374, 396
 (*Asthenosoma intermedium*) 374
 (*Asthenosoma varium*) 396
 fish doctor parasites 392
 fisheries 2, 22, 24-27, 34-35, 163, 187-188, 254, 299, 312, 321, 329-332, 337-341, 350, 352, 427-428, 436, 441-442, 444, 451, 498-499
 fishes 27-28, 54, 113, 312, 314, 318, 321, 349, 376, 379-381, 383-384, 399, 420, 437, 497-499
 anadromous 349-351, 384, 390-391, 398, 400, 431, 443-444, 450
 bony 312, 314, 368, 383, 398-399
 cartilaginous 314, 320
 catadromous 349-351, 384, 390-391, 398, 400, 431, 450
 collection of 27, 35, 51, 53-54, 59, 305, 318, 439, 444, 499
 fish fluke 393
Fistularia commersonii (cornetfish) 378
 fjords 88, 122, 132, 259, 262-263, 290, 302, 325, 332, 338, 341-343, 345-346, 351
Flabellina rubrolineata (nudibranch) 365
 flagella 293, 308
 flagellates 308, 329-330, 335-336, 350-351, 358
 flamboyant cuttlefish (*Metasepia pfefferi*) 355, 388
 flasher scorpionfish (*Scorpaenopsis macrochir*) 392
 floats 22, 27, 32, 35, 43, 50-52, 54, 56-57, 59, 64-67, 77, 89-90, 107, 109-110, 116-117, 163, 185, 226, 230, 291-292, 388, 409, 417, 420, 424, 444, 456, 458-459
 flood currents 235, 249
 floods 156, 162-163, 235, 281-282, 341, 345-346
 flora 305, 321, 412-413
 Flores, Indonesia 16, 229
 Florida 33, 54, 117, 123, 130, 164, 167, 170-171, 179, 184, 191-192, 239, 259, 262, 276, 315, 337, 423, 446, 475
 Florida Current 184
 Florida, Straits of 130
 flounder, *Bothus sp.* 379
 flounder, flowery (*Bothus mancus*) 312
 fluids, mixing of 37, 63, 93, 119, 145, 179, 455
 fluke, fish 393
 fluorine 100
 flyingfishes 383
Foa brachygramma (weed cardinalfish) 396

- focus, of earthquakes 29, 33, 38, 293, 398, 427, 474, 477
 fog 151, 173-174, 328
 Folger, Timothy 19
 food chains 3, 298-299, 306, 321, 334, 349, 496-497
 food webs 299, 304, 319, 330, 340, 431, 433, 451
 foreshore 266-267, 269, 272-273, 282
 forked caudal fins 380-381, 399
 fossil fuels 2-3, 13, 29, 31, 33, 103, 120, 128, 200, 204-205, 284, 436, 472, 474
 fossil record 5, 141
 fossils 20, 69, 73, 130, 134, 139-141, 229, 469
 fouling 39, 59, 302, 339, 440-441, 444
 fracture zones 43, 77, 80-81, 88, 91
 fragmentation 385
 France 24, 33, 45, 163, 253-254
 Franklin, Benjamin 19
 Fraser River, BC, Canada 134
 freezing point 96, 103-104, 106-109, 148, 325, 467-468
 frequency 210
 freshwater, also runoff 65, 94
 fringing reefs 84-85, 225, 264, 280, 283, 408
 frogfishes 368-370, 379, 381, 388, 416
 - Lembeh (*Antennarius sp.*) 388
 - sargassumfish (*Histrio histrio*) 416
 - striated (*Antennarius striatus*) 369
 fronts
 - between water masses 191
 - cold 172-173
 frustules 125-126, 137, 142, 296, 307-308, 320, 335-336
 Fukushima, Japan" 441-443
 fundamental niches 404, 415-416, 424
 Fundy, Bay of 250, 254, 259
 fungi 125, 288, 290-291, 297, 303, 356, 365-366
 fur seal, Antarctic (*Arctocephalus gazella*) 418
 fusion, latent heat of 104-106, 109, 116-117, 466-467
Gadus morrhua (Atlantic cod) 312, 498
 Gakkel Ridge 78, 421
 Galveston, TX 28, 170, 239, 259, 276-277, 284, 444
 Ganges River 89, 121, 281, 325
 gas, gases
 - dissolved 4, 49, 57, 99-103, 116, 124, 127-128, 130, 139, 142, 194, 197, 289-290, 293, 297, 301-302, 320-321, 356, 429, 431, 446-448, 451, 474
 - greenhouse 3, 35, 164-165, 216, 284, 428, 444-446, 448, 472-475, 477
 - natural 25, 28-29, 31, 34-36, 45, 85, 89, 143, 281, 302, 304, 423, 443
 - transfer between oceans and atmosphere 101*Gastrolepidia clavigera* (scale worm) 396
 gastropods 358, 365, 376, 397, 414
 gelatinous holoplankton 310
 gelbstoff 101
 generators, wave energy 32-33
 genetic diversity 27, 384-385, 391, 399, 499-500
 genetics 25, 27, 34, 54, 288-289, 292, 312, 384-385, 390-391, 399, 423, 433, 497, 499-500, 503
Genicanthus melanospilos (black-spot angelfish) 381
 genus, in taxonomy 288, 291, 307, 412, 416, 420, 423
 geological record 76
 geology 2, 13, 20, 421, 464
 Georges Bank 332
 Georgia, GA 76, 191, 239, 319, 418
 geostrophic flow 145, 168, 179, 184, 186, 188, 191, 209, 230, 455, 491-492
 Germany 17, 23, 45
 giant clam (*Tridacna gigas*) 396-398
 Gibraltar 131, 197, 199, 470
 Gibraltar, Straits of 131, 197, 199, 470
 gills 315, 384, 439
 glacial flour 122-123
 glacial maxima 86
 glaciation 120, 460
 glaciers 64, 88, 91, 120, 122-123, 137, 142, 201, 260, 262-263, 341-342, 445-446, 460
 Global Positioning System (GPS) 37-38, 50-51, 58
 global warming 5, 86, 164, 177, 207, 444-445, 461, 472, 474
 Glomar Challenger 45
Gnathophylloides mineri (urchin shrimp) 396
 goatfishes, blackstriped (*Upeneus tragula*) 367
 Gobi Desert 123
 gobies 367-369, 372, 374, 382-383, 392, 396-397
 - fire (*Nemateleotris magnifica*) 369
 - Old Glory (*Amblygobius rainfordi*) 382
 - whip (*Bryaninops yongei*) 392
 - yellow shrimp (*Cryptocentrus cinctus*) 397
 GoFlo bottle 47-48
 gold 27, 30-31, 100, 422
 Goldman's sweetlips (*Plectorhinchus goldmanni*) 383
 Gondwanaland 69, 89
 Gorda Plate 73
 Gorgonocephalidae (basket stars) 364
 GPS (Global Positioning System) 37-38, 50-51, 58
 grab samplers, 44-45, 54, 59-60
 graded beds 133, 142
 grain size 120, 131, 133-134, 142-143, 273, 282, 404, 466
 Grand Cayman Island 145
 granite 65, 269
 grapeweed (*Caulerpa racemosa*) 326
 graphs, interpretation of 7, 13-14, 478
 grasses 267-268, 274, 280, 282, 288, 306, 318, 366
 gravel 29-31, 120, 132, 142, 282-283, 323, 360, 390-391
 gravity 44, 211, 222, 488
 - buoyancy of fishes and 384
 - in longshore drift 270
 - sedimentation and 124
 - surface tension and 110
 - tides and 254
 - vertical mixing of water inhibited by 197
 - waves and 180, 211-212
 gravity corers 44-45
 gray reef shark (*Carcharhinus amblyrhynchos*) 313, 381
 grazers, grazing 297, 300, 307, 317-318, 330, 336, 357, 364-365, 399, 411-412, 415-416, 424, 430
 Great Barrier Reef 280
 Great Britain, United Kingdom 23, 25, 45, 221, 441
 great circle 10
 Great Lakes of North America 232
 great white shark (*Carcharodon carcharias*) 27, 313
 Greece 76, 339
 Greeks, Ancient 17, 86, 340-341

- greenhouse effect 3, 15, 102-103, 106, 146, 150, 179, 216, 461
 greenhouse gases 3, 164-165, 216, 284, 428, 444-446, 472-475, 477
 Greenland 3, 12, 18, 78, 82, 88-89, 122, 198-201, 205-206, 297,
 441, 445-446
 Greenland Sea 198
 Greenwich, England (near London) 9-10, 14
 groins 277-279, 282, 432
 Groundwater 94, 117, 150, 290, 432-434, 446, 462
 grunion (*Leuresthes tenuis*) 253, 388-389
 Guam 24, 259
 Gulf Stream 19, 33, 157, 167, 173, 184, 187, 189-193, 199, 201,
 206-207, 230, 349, 390-391, 466
 guyots 84
Gymnosarda unicolor (dogtooth tuna) 312
Gymnothorax fimbriatus (darkspotted moray eel) 382
 gyres 181, 185-191, 205-207, 332, 416, 440
 subpolar (high-latitude) 189, 205
 subtropical 157, 181, 185-189, 191, 193, 207, 296, 301, 320,
 390, 416, 440
 habitats 13, 27, 35, 54-55, 59, 252, 274, 280, 318, 338, 349,
 355-357, 366, 370, 389, 391, 397-398, 400, 416, 424, 427,
 431, 443-444, 448, 450-452, 494, 499-500
 hadal zone 303, 320
Haddon's sea anemone (*Stichodactyla haddoni*) 377
 Hadley cells 152, 156, 158-159, 166, 175, 185
 hadopelagic zone 305
 half-life 204, 468-469
Halimeda sp. (algae) 270, 396
 haloclines 183, 195, 198-199, 324-325, 328, 332-333, 343, 345-346,
 348-351, 417, 424
Hapalochlaena sp. (blue-ringed octopus) 287, 376
 harbor seal (*Phoca vitulina*) 316
 harbors 214, 227, 233, 235, 278-279, 282, 316, 342, 438
 hard parts 3, 97, 99, 117, 120-121, 124-127, 142, 296, 303, 310,
 319-320, 333, 361, 406, 408, 424
 harmonics 232
 harp shell (*Harpa major*) 358
Harpa major (harp shell) 358
 hatchetfish 419
 Hawaii 2-3, 18-19, 23-24, 32-33, 63, 66-67, 80, 82-83, 119, 130,
 133, 164, 174-175, 225, 227, 229, 259-261, 266, 269-270,
 283, 317, 326, 366, 372, 375, 379-380, 388, 391, 429
 Hawaiian Island-Emperor Seamount chain 81-83, 85
 hawkfishes 368-369, 408
 Falco (*Cirrhites falco*) 369
 longnose (*Oxycirrhitus typus*) 408
 headlands 222-223, 228, 232, 264-266, 269, 271, 273, 275, 283
 Heard Island 115
 heat
 Earth's budget of 149-150
 latent 96, 104-106, 109, 116-118, 148-151, 170, 175-176,
 466-467
 sensible 104, 106, 117, 150, 172
 heat capacity 93, 96, 104-106, 116-118, 146, 154, 156, 166, 173,
 175, 217, 444, 466-467
 heat transfer 147, 150-151, 175, 462, 466, 475-476, 478
 Heezen, Bruce 21, 42, 58, 60
 helium 37, 66, 94, 100, 440, 458
 herbicides 431
 herbivores 290-291, 297, 299, 303, 305, 308, 319, 330, 334, 336,
 358, 364, 415
 hermaphroditism 385
 hermatypic (reef-building) corals 85, 263, 279, 282, 333, 361,
 404-405, 408, 424, 429
Hermissenda crassicornis (horned nudibranch) 410
 hermit crabs 396-397, 414, 416
 Herodotus 16-17, 72
 herring gull (*Larus argentatus*) 319
 herrings 299, 312, 314
Heteractis magnifica (anemone) 363
 heterocercal caudal fins 381, 399
 heterotrophs 288-291, 297, 318-319
 high seas 22, 25, 27, 34-35, 444
 high-latitude gyres 181, 185
 high-pressure zones 152, 154, 156, 161-162, 164, 168, 491-493
 high-tide line 235, 267, 269, 273, 304, 318, 388-389, 412, 415
 high-tide zone 412, 415-416, 424
 hills, abyssal 65, 84
 Hilo, Hawaii 174-175
 Himalaya Mountains 71, 76, 89-90, 156
Hippocampus bargibanti (pygmy seahorse) 370
Hippocampus kuda (spotted seahorse) 370
Hippolyte commensalis (humpbacked shrimp) 396
Histrio histrio (sargassumfish) 416
 HIV/AIDS virus 27, 432
 holoplankton 308-311, 320
 Homer, AK 274
 hominids 6
Homo erectus 16
Homo sapiens 6, 288
 Honolulu, Hawaii 175
 horned nudibranch (*Hermissenda crassicornis*) 410
 horned sea star (*Protoreaster nodosus*) 407
 horse latitudes 152, 158
 horseshoe crab (*Limulus polyphemus*) 388
 hot spots 66-67, 70, 81-84, 89-90, 129, 260-261, 280, 460
 Huang (Yellow) River 122
 Hudson Bay, Canada 90
 Hudson River 250, 342
Huenia heraldica (arrowhead crab) 396
 Hugo, Hurricane 170
 humidity 412, 415, 446, 480
 humpback whale (*Megaptera novaengliae*) 315
 humpbacked shrimp (*Hippolyte commensalis*) 396
 hunting and defense 17, 26, 35, 41, 55, 277, 296, 304, 307,
 316-318, 332, 336, 340, 352, 356-359, 367-370, 372,
 375-376, 378-379, 382-385, 389-390, 398-399, 412, 415,
 418, 420, 424-425, 497-498, 501
 camouflage in 368, 370, 372, 396, 399-400
 concealment in 368, 372, 374, 376, 399
 group cooperation in 308, 312, 368, 378-379, 398-399
 lures in 54, 368-370, 381, 399, 419
 poisons in 336, 356, 368, 376, 399-400
 speed in 368
 spines and armor in 110, 293, 356, 368, 372, 375-376,
 381-382, 396-397, 399
 hurricanes 1-2, 58, 121, 145, 149, 151, 161, 164, 168-172, 176-177,
 215-216, 227, 232, 276, 281, 283-284, 467, 475, 477, 500
 hydration 97, 117
 hydrocarbons 101, 304, 423, 425, 434, 436, 452

- hydrogen 5-6, 13, 34, 65, 94-97, 103-107, 109-110, 116-117, 139, 203-204, 289-290, 293, 302, 320, 346, 351, 356, 422-423, 425, 428-429, 441, 494-496
- hydrogen bonds 95-97, 103-107, 110, 116-117
- hydrogen sulfide 6, 289-290, 302, 320, 346, 351, 356, 422-423, 425, 429
- hydrogenous sediment 120, 128, 130-132, 134, 142
- hydrographic surveys 19
- hydrographic wire 48
- hydroids 365, 376, 396, 403, 416, 422
- hydrologic cycles 94, 441
- hydrophones 45, 115, 117
- hydrosphere 64-65
- hydrostatic pressure 281
- hydrothermal minerals 31, 128-129, 137
- hydrothermal vents 5, 21, 31, 54, 56, 97, 101, 108, 117, 128-130, 137, 142-143, 203, 288, 290, 293, 299, 304-305, 318, 356-357, 398, 421-423, 425-426
- Hydrurga leptonyx*, Leopard seal 418
- Hymenocera elegans* (harlequin shrimp) 357
- hypoxia 337-339, 350, 430, 448-449, 451
- Hypselodoris bullocki* (nudibranch) 388
- ice
- density of 107, 109
 - formation of 108, 468
 - heat-buffering effect of 106
- ice ages 86, 88, 91, 122, 128, 201, 281, 341, 446, 458, 462, 472, 475
- ice algae 417, 419, 424
- ice exclusion 165, 197-198, 206, 332, 417, 424
- ice sheets 3, 86, 88, 94, 139, 153, 198, 201, 333, 419, 445-446, 461, 467, 475
- ice-rafterd sediment 137
- Iceland 17-18, 25, 78, 82, 164, 201, 206
- Icelandic Ridge 82
- iguana, marine (*Amblyrhynchus cristatus*) 317
- in situ measurements 59, 204
- incidence, angle of 150-151, 293
- incubation 385
- incurrent openings 311, 358, 363
- India 302
- Indian Ocean 19-20, 25, 34, 89-90, 115, 121, 137, 154, 156-157, 160, 164, 171, 185-186, 193, 198, 201, 215, 226-229, 247, 302, 305, 327
- Indo-Australian Plate 76, 89
- Indonesia 16, 31, 66, 74-75, 141, 160-163, 175, 227-229, 260, 287, 310, 314, 317, 327, 358, 361, 363-365, 367, 369-370, 372, 374, 377, 388, 392, 396-397, 407
- Indonesian Arc 89-90
- Indus River 89, 121
- Industrial Revolution 3, 13, 204, 302, 427, 444
- industrial waste 25, 336, 427, 432
- inertial currents 194, 206
- inertial period 481, 489-490
- infauna 304, 356, 366, 398, 450
- innkeeper worm (*Urechis caupo*) 366-367
- interference, in waves 210, 219-220, 232
- intermediate waves 222
- internal waves 58, 200-201, 229-230, 233-235, 326, 331, 343, 345, 350
- International Ocean Drilling Program (IODP) 45, 72
- International Seabed Authority (ISA) 24
- International System of Units (SI) 12, 14, 100, 104
- interstitial (pore) water 29, 139, 143, 290, 303, 366, 399, 424, 446
- intertidal (littoral) zone 235, 252, 268-269, 272, 282, 304, 318, 320, 356-357, 398, 403, 412, 414, 424
- intertropical convergence zone (ITCZ, doldrums) 152, 180, 189
- inverse estuaries 343, 346, 351
- invertebrates 54, 309, 312, 335-336, 349, 363, 367, 372, 376, 383-385, 398-399, 406, 408, 411, 421-422, 424
- iodine 100, 104, 441
- ionic bonds 95-97, 117
- ions 13, 95, 97, 99, 103, 108, 110, 116-117, 128-129, 287, 289, 294-296, 302, 307, 330, 383-384, 467, 470, 495-496
- complexed 440-441, 502
- Iran 76
- iridium 100, 141
- Iron 289, 422
- iron oxide 129, 137
- ironshore 264
- Irrawaddy River 121
- island (mountain) effect 165, 174-175
- islands, barrier 2, 259-260, 262, 265, 269, 274-278, 282-284, 341-342, 350
- islands, sedimentary and magmatic arc 74-75, 84, 89-90, 97, 260
- islands, volcanic 74-75, 82, 84, 89-90, 229, 260-261, 280
- isobars 7, 491-493
- isopods 412, 415, 424
- isopycnals 7
- isostasy 63, 65, 119, 257, 455, 458-459
- isostatic leveling 82, 85, 88, 90-91, 261-264, 277, 458, 460-462
- isotherms 7, 156-157
- isotopes 101, 117, 139-140, 203, 441, 468-469
- Israel 17, 176
- Italy 17, 339
- Ivan, Hurricane 215
- Jalisco, Mexico 229
- Jamaica 342
- Jamaica Bay 342
- Japan 25, 31, 34, 40, 45, 71-72, 74, 141, 157, 164, 167, 199, 207, 209, 227-229, 339, 350, 432, 437, 441-442, 450-451
- Japan (Kuroshio) Current 157, 167, 187, 193, 349
- Japan, Sea of 339, 441, 451
- Jason II ROV 55, 57
- Jason Jr. ROV 57
- Java 75, 90, 227, 229, 420
- Java Sea 90
- jellyfish 6, 26, 310-311
- jet streams 123, 152, 164, 230
- jetties 278-279, 282, 284
- Johnson Sea Link 54
- JOIDES Resolution 45
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) 428
- joule (J) 104, 117
- juveniles, of marine organisms 274, 280, 282, 307-308, 311, 314, 319-320, 334-335, 340, 349-350, 372, 385, 389-391, 393, 431, 444, 496, 499, 501-502
- Kahoolawe, Hawaii 175
- Kailua-Kona, Hawaii 174-175
- Katrina, Hurricane 170, 281

- Kauai, Hawaii 259, 283
 Kealakekua Bay, Hawaii 19
 Keeling Atoll 85
 kelp 291-292, 306, 318, 323, 326, 356, 409-412, 416, 424-426
 kelp forests 318, 356, 409-412, 424-426
 Kelvin waves 230, 232-233
Kentrodoris rubescens (nudibranch) 388
 Kilauea volcano 63, 80, 82, 260-261, 270
 killer whale (*Orcinus orca*) 299, 315, 317, 411
 kinetic energy 180, 182, 205, 211-212, 223
 king crab 3, 26, 311
 Kona, Hawaii 32
 Krakatau (Krakatoa) 74-75, 124, 140, 227, 229
 krill 299-300, 309-310, 352, 357, 418
 Kuril Islands 25
 Kuroshio (Japan) Current 157, 167, 187, 193, 349
 La Rance, France (English Channel, French coast) 33, 253-254
Labroides phthirophagus (cleaner wrasse) 372
 lagoons 31, 84-86, 134, 233, 260, 274-276, 280, 282, 318, 323-325, 342, 391, 406-407, 424
 Laguna Madre, TX (south of Galveston) 346
 Lanai, Hawaii 229
 land-ocean-atmosphere interactions 175
 landfills 432, 434, 437
 Landsat satellite 347
 landslides 79, 120, 124, 212, 227, 260-261, 282
 Langmuir circulation 194-195, 206, 307, 326, 331, 345
 lanternfish 419
Larus argentatus (herring gull) 319
 larvae 3, 252, 311-312, 320, 331, 335, 340, 349, 357, 385, 388-391, 393, 399, 423, 447, 499
 lasers 58, 111
 Lassen, Mount, CA (near CA-OR border) 73
 latent heat of fusion 104-106, 109, 116-117, 466-467
 latent heat of vaporization 96, 104-106, 116-118, 148, 150-151, 175, 466-467
 lateral line 398
Laticauda colubrine (banded sea snake) 317
 latitude 9-10, 151, 158, 166, 201, 245, 305, 467
 latitudinal imbalance, of Earth's heat energy 149, 175
 latitudinal transfer, of heat 1, 15, 93, 145, 200, 209, 323, 455, 466
 latitudinal variation, of marine environments 305
 lava 47, 63, 77-78, 80, 82, 97, 175, 259-261, 270, 415
 Law of the Sea conferences 22-25, 31, 34, 36
 Law of the Sea Treaty (LOS) 23-25, 31, 34, 36, 438
 leaching 117, 120, 129
 Lebanon 17
 leeward 85, 174-176, 213, 408
 Lembeh frogfish (*Antennarius sp.*) 388
 lemon damselfish (*Pomacentrus moluccensis*) 392
 Leopard seal, *Hydrurga leptonyx* 418
Leuresthes tenuis (grunion) 253, 388-389
 levees 30, 263, 281-283, 342, 429, 431
 lichens 412, 424
 light
 infrared 38, 110-112, 149-150, 192, 446, 471-474
 primary production and 1, 37, 63, 85, 93, 111, 119, 287, 289, 355, 403, 427, 430, 455, 493-494
 ultraviolet 5, 38, 110-112, 147, 150, 293, 471-473, 495
 underwater transmission of 110, 117
 light-limited productivity 1, 37, 63, 93, 119, 287, 355, 403, 427, 455, 493
 limestone 16, 130, 406, 423
 limiting nutrients 294-296, 302, 319, 321, 430
 limpets 412, 414-415, 422, 424
Limulus polyphemus (horseshoe crab) 388
Linckia laevigata (sea star), 392
 lined chiton (*Tonicella lineata*) 414
 lionfishes 381-382
 zebra (*Dendrochirus zebra*) 382
 lipids 101
 lithogenous (terrigenous) sediment 86, 120-124, 127-128, 130-131, 133-137, 142, 294, 303, 336
 lithosphere 64-67, 71, 73-79, 81, 84, 90, 459
 lithospheric plates 45, 64-67, 69, 71, 77, 79, 82-83, 85, 90-91, 97, 260-261, 443, 458-460, 480
 lithospheric upwelling 64, 67, 70-71, 74-81, 83-86, 89-91, 97, 127-130, 133, 137, 139, 142, 199-200, 245, 260, 280, 290, 421-423, 425-426, 460-461
 litter 129, 280, 357, 440
 littoral (intertidal) zone 235, 252, 268-269, 272, 282, 304, 318, 320, 356-357, 398, 403, 412, 414, 424
 littoral (longshore) drift 33, 134, 270-271, 273-279, 282, 341-342
Littorina sp. (periwinkles) 412, 415, 424
 lizardfishes 368-369
 twospot (*Synodus binotatus*) 369
Lobodon carcinophagus, Crabeater seal 418
 lobster pots 53-54, 314
 lobsters 53-54, 116, 309, 311, 314, 376
 log plots 7
 logarithmic scales 7, 103, 308
 Loihi Seamount, Hawaii 82, 260
 Loma Prieta earthquake 43, 80, 133, 141, 260, 281
 Long Island Sound 251-252
 Long Island, NY 251-252, 278, 331
 Long Valley caldera 124
 Long Valley, CA (east of San Francisco near C-NV border) 124
 longitude 9-10, 13-14, 16-18, 243, 476
 longnose hawkfish (*Oxycirrhites typus*) 408
 longshore (littoral) drift 33, 134, 270-271, 273-279, 282, 341-342
 longshore bars 225, 267, 269, 272-273, 275, 277, 282
 longshore currents 194, 217, 271
 Lorenz, Edward 478, 480
 Lorenzian waterwheel 478-479
 Los Angeles, CA 438
 Louisiana (LA) 143, 170, 282, 423
 low-pressure zones 151-152, 154, 156, 161-162, 168-170, 172, 176, 191, 193, 230, 491-492
 low-tide lines 235, 252, 265, 267, 269, 273, 280, 282, 304, 406, 412
 low-tide terrace 269
 low-tide zone 412, 416, 424
 lugworm (*Arenicola brasiliensis*) 366
 lunar month 242, 244, 254
 lunate caudal fins 381, 399
 lures, in hunting and defense 54, 368-370, 381, 399, 419
 Macdonald Seamount chain 82
 Macedonia (Balkans) 76
 Mackenzie delta, Yukon, Canada 281
 mackerel 299, 384, 497
 macroalgae 291, 306-307, 326, 349, 364-365, 385, 399, 405, 409,

- 415-416, 424
Macrocystis sp. (kelp) 291, 326
 Madagascar 89, 156
 Madden-Julian Oscillation (MJO) 163-164
 Magellan, Ferdinand 18
 magma 65, 67, 71, 73-79, 82-83, 90, 421, 425
 magmatic arcs 74-75, 84, 89-90, 260
 magmatic rocks 79, 83, 425
 magnesium 98-100, 130, 289, 293, 422, 425, 495
 magnetic fields 66, 83, 138, 398, 400
 magnetism 69
 maine (ME) 174, 332, 415
 Maine, Gulf of 332
 Majidae (crabs) 370
 major constituents, of seawater 99-100
 malaria 438, 452
 Malaysia 24
 Malibu Beach, CA (north of Los Angeles) 271
 mammals, marine 316, 318, 368, 418, 443
 manatee (*Trichechus manatus*) 365
 mandarinfish (*Synchiropus splendidus*) 388
 manganese 22, 24, 30-31, 47, 98, 100, 128-130, 139, 142, 289, 421-422
 manganese nodules 22, 24, 30-31, 47, 128-130, 142
 mangroves, mangrove swamps 2, 101, 259-260, 268, 274, 280, 288, 349, 403, 431, 450
Manta birostris (manta ray) 313, 315, 383, 396, 408
 mantle, Earth's 64-67, 71, 73-74, 76-79, 81-82, 86, 90-91, 97, 128, 397, 455, 459-460, 462-464
 maps, mapping 1, 6-14, 16-19, 21, 23, 38-45, 57-60, 91, 168, 172, 184-185, 193, 198, 230, 233, 261, 338, 429, 437, 491-492
 marginal seas 29, 79, 85, 89-90, 99, 121-122, 130, 134, 159, 175, 324-325, 338, 417
Marginopora vertebralis (foraminifera) 126
 margins, continental 71, 85-86, 88, 97, 121, 134-135, 142
 Mariana Arc 129, 421
 Mariana Islands 74
 Mariana Trench 20, 56, 75
 mariculture 27
 marine mammals 316, 318, 368, 418, 443, 450
 marine organisms
 behavior of, 54
 chemical sensing in 388, 398
 classification of 288
 colonial 310-311, 358, 363-364, 378, 385, 399
 communication in 397, 400
 density of 420
 detritus of 124, 363
 distribution of 305
 diversity of 384, 405, 431, 499-500
 effects of toxins on 433, 450, 452, 501-502
 excretions from 101, 117, 291, 295, 319, 383, 432-433
 eyes in 398
 fouling by 39, 59, 440-441, 444
 hard parts of 3, 97, 99, 117, 120-121, 124-127, 142, 296, 303, 310, 319-320, 333, 361, 406, 408, 424
 magnetic fields sensed by 398
 navigation in 397, 400
 oviparous 385
 ovoviviparous 385
 pelagic 53-54, 59, 126, 135, 299-300, 303-305, 312, 318, 320-321, 356, 358, 364, 372, 378, 384-385, 388-390, 398-400, 418-419, 431, 444
 siliceous 120, 125-127, 135-137, 139, 142, 296, 307
 tides and 252
 viviparous 388, 412
 wetlands and 2, 30, 35, 132, 134, 267, 280-283, 342, 348-349, 351, 366, 431-432, 443, 446, 450-451
 marlin 381
 marsh grass, *Spartina* sp. 365
 marshes, salt 85, 101, 260, 280, 290, 349
 Maryland (MD) 133, 274, 337
 mass extinction 2, 13, 140-141, 445, 449
 mass wasting 124
 Massachusetts (MA) 42, 167, 239, 259, 324
 mathematical modeling 58-59, 163, 186, 243-245, 302, 444, 474-478, 480
 Maui, Hawaii 269
 Mauna Loa, Hawaii 2, 82
 Maury, Matthew Fontaine 19
 maximum sustainable yield 15, 26-27, 323, 340, 350, 352, 403, 455, 497-499
 meanders 152, 192-193, 206, 230
 of Gulf Stream 192-193, 206
 of jet streams 152-153, 172, 176, 230, 417
 mechanical current meters 51
 Medea ROV 55, 57
 Mediterranean Sea 17-18, 34, 72, 89-90, 130-131, 133-134, 159, 164, 196-199, 206-207, 324, 346, 390-391, 470
Megaptera novaengliae (humpback whale) 315
 Mekong River, Delta 122
Melithaea sp. (gorgonian sea fan) 363
 menhaden 26, 312, 337
 Mercator projection 10-12, 14, 16, 41
 mercury 48, 94, 100-101, 110, 336, 428, 433, 437, 456
 Meridional Overturning Circulation (MOC) 193, 200-201, 206, 230, 235, 302, 339, 445-446, 448
 meroplankton 308-309, 311-312, 320, 385, 389, 399
 mesopelagic zone 305
 mesoscale eddies 192-193, 206, 307, 329
 mesosphere 147
 metacercaria 393
 metamorphosis 303
Metasepia pfefferi (flamboyant cuttlefish) 355, 388
 meteorites 5, 66, 120, 131-132, 140-142, 212, 227, 229
 meters, current 50-53, 59, 248
 methane 3, 5, 25, 29, 31, 34-35, 94, 103, 132, 289-290, 304, 424-425, 446, 471, 474
 methane hydrates 25, 29, 31, 34-35, 132, 446
 methylmercury 433, 437, 450
 Mexico 28, 73, 141, 164, 170, 179, 229, 241, 249, 255, 262, 338-339
 Gulf of
 dead zone in 339
 oil rigs in 25, 28-29, 34-35, 443
 Gulf of CA 179
 Miami Beach, FL 276, 284
 Miami, FL 276, 284
 Microalgae 349, 364, 399, 405, 430, 442
 Micronesia 17, 34
 Micronesians 17-18, 35

- micronutrients 330, 417
 microorganisms 5-6, 13, 54, 110, 133, 290-292, 303, 356, 407, 432, 452
 mid latitudes 172, 182, 194, 196, 327, 335, 413, 445
 Mid-Atlantic Ridge 15, 71, 77, 85, 89-90, 130
 Middle East 86
 middle-tide zone 412, 415-416, 424
 migration, and reproduction 154, 282, 298, 309, 389-391
 mimic surgeonfish (*Acanthurus pyroferus*) 372
 mimicry 368, 370, 372
 Minamata, Japan 432, 437-438, 450
 Mindoro Island, Philippines 229
 mining, seafloor 23-25, 30-31, 35, 120, 128-129, 323, 422
 Minoan civilization 17, 229
 minor constituents, of seawater 100-101
 miracidium 393
Mirounga angustirostris (elephant seal) 27, 316-317, 433
 Mississippi (MS) 5, 122, 170, 201, 263, 281-283, 339, 342, 436, 444
 Mississippi River 263, 283, 339, 342, 436
 Mississippi Sound 444
 mixed (surface) layer, of ocean water 3, 183, 188, 190, 194-195, 197, 203-204, 206, 289, 298-300, 304, 316, 319, 321, 324-325, 331-335, 337, 348, 350, 425, 466, 476
 mixed tides 239-243, 248-249, 254-255, 389
 mixing, of water masses 50, 200, 202-207, 298, 441
Mnemiopsis leidyi (ctenophore) 310
 MOC (Meridional Overturning Circulation) 193, 200-201, 206, 230, 235, 302, 339, 445-446, 448
 modeling, mathematical 58-59, 163, 186, 243-245, 302, 444, 474-478, 480
 molecules
 clustering of 108-109, 378, 467
 friction between 180
 polar 96, 104
 water 6, 94-97, 103-104, 106-111, 116-117, 139-140, 147-148, 180, 197, 203, 211-212, 216-217, 219, 221, 223, 383, 441, 464, 467, 491, 496
 mollusks 315, 359-360, 376, 396, 406
 bivalve 359-360, 376, 393, 406
 gastropod 358, 365, 376, 397, 414
 Molokai, Hawaii 266
 molybdenum 31, 100
 monsoons 18, 156-157, 160, 165, 283, 325
 Montenegro (Balkans) 76
 Monterey 26, 43, 133, 257, 259, 265-267, 291, 316, 319, 326, 361, 409-410, 414, 430
 month, lunar 242, 244, 254
 Montrose Chemical Corporation 438
 moon
 declination of 242-245, 254
 gravitational attraction of 212-213, 236, 254
 moon wrasse (*Thalassoma lunare*), 382
 moraines (deposition sites) 262-263
 moray eels 382-384
 mosquitoes 110, 438
 Moss Landing Power Plant, CA (near Monterey) 430
 mountain (island) effect 165, 174-175
 mountain ranges 39, 63, 65, 69, 73, 80, 121, 159, 167, 174-175, 263
 mud snail (*Nassarius papillosus*) 375
 multibeam sonar 42-43
 mussels 336, 349, 360-361, 389, 414-416, 421-422, 424
 California (*Mytilus californianus*) 316, 361, 389, 414
 common (*Mytilus edulis*) 389
 mutagens 433, 450, 501, 503
Mytilus californianus (California mussel) 316, 361, 389, 414
Mytilus edulis (common mussel) 389
 NADW (North Atlantic Deep Water) 198, 200-201, 203-204, 206-207, 297
 Nansen bottles 48
 Nansen Fracture Zone 88
 Nansen, Fridtjof 181
 narcosis 55, 384
Nassarius papillosus (mud snail) 375
 National Academy of Sciences 430
Nautilus pompilius (chambered nautilus) 314, 316, 420
 navigation, in marine organisms 397, 400
 Navy, U.S. 19, 28, 215, 443
 neap tides 241-244, 254-255, 389
 nearshore 29, 33, 131-132, 134, 142, 173, 191, 195, 264, 267, 337, 348, 429, 436, 443
Nebrius concolor (nurse shark) 313, 315
 nekton 308, 311-312, 320-321, 330-331, 338, 358-359
 Nemanthus annamensis (colonial anemone) 363
Nemateleotris magnifica (fire goby) 369
Nembrotha rutilans (nudibranch) 388
 neritic province 304, 320
 nets, collection 27, 35, 51, 53-54, 59, 305, 318, 439, 444, 499
 neurotoxic shellfish poisoning (NSP) 336
 neutrons 94
 Nevada (NV) 121, 159, 174, 177
 New Brunswick, Bay of Fundy, Canada 259
 New England coast 332
 New Jersey (NJ) 230, 265, 277, 331, 337-338, 432
 New Orleans, LA 170, 281
 New York (NY) 91, 230, 239, 241, 249-250, 278, 338, 342, 429, 432, 480
 New York Harbor 249-250, 342, 429
 New Zealand 19, 31, 262-263, 268, 342
 Newfoundland 18
 Newton, Isaac 235-236
 Nicaragua 229
 niches
 ecological 404, 413, 500
 fundamental 404, 415-416, 424
 survival 404, 424
 nickel 31, 64, 66, 94, 100, 128-129
 Niger delta 281
 Nigeria 281
 Nile delta 281
 Ninety East Ridge 89
 nitrates 57, 99, 139, 289, 294-297, 302, 336, 422, 476, 495
 nitrogen 65, 100-102, 148, 296, 495
 as nutrient, in photosynthesis 139, 189, 289, 291-292, 294-299, 301-302, 307, 319, 321, 327, 330-336, 338, 349-350, 405-406, 409, 416-417, 424, 430, 436, 448-450, 501
 biogeochemical cycle of 295
 nitrogen narcosis 55, 384
 noble gases 94
 nodes, of standing waves 231-233, 246-247, 249-252

nODULES

- manganese 22, 24, 30-31, 47, 128-130, 142
- phosphorite 30-31, 47, 128, 130, 142

noise, ocean 116

- nonconservative properties of seawater 203, 206
- nonindigenous species 427, 431, 443, 451
- nonlinear relationships 7, 13, 341, 475, 477-480
- nonpoint sources of pollution 436, 450
- North American Plate 69, 71, 73-74, 80
- North Atlantic Deep Water (NADW) 198, 200-201, 203-204, 206-207, 297

North Atlantic Gyre 390, 424

North Atlantic Oscillation (NAO) 164

North Carolina (NC) 324, 342

North Equatorial Current 186

North Pacific Gyre 349, 391, 440

North Pole 9-10, 14, 77, 89, 138, 242, 481-482, 484

North Sea 42, 90, 249, 389-390

North Star 9, 17

northern kelp crab (*Pugettia producta*) 410

Norway 17, 33, 88, 133, 262, 389-390

Norwegian Sea 198

Nova Scotia, Canada 46, 133, 241, 250, 254

nucleus, of atoms 94-96

nudibranchs 37, 365, 376, 385, 388, 396, 400, 410-411, 416

Flabellina rubrolineata 365horned (*Hermisenda crassicornis*) 410*Hypselodoris bullocki* 388*Kentrodoris rubescens* 388*Nembrotha rutilans* 388nurse shark (*Nebrius concolor*) 313, 315

nutrient-limited 294-296, 299, 302, 319, 321, 330, 332-334, 430

nutrients 139, 189, 289, 291-292, 294-299, 301-302, 307, 319, 321, 327, 330-336, 338, 349-350, 405-406, 409, 416-417, 424, 430, 436, 448-450, 501

anthropogenic 5, 290, 302, 337-339, 350, 352, 427, 429-430, 435-436, 448-451

in coastal zones, 294, 327, 330-331, 350

in estuaries 349

limiting, 294-296, 302, 319, 321, 333, 430, 495

primary production and 293-296, 319, 335, 350

recycling of 295, 335, 350

transport of 296

uptake of 294

vertical distribution of 298-299

Oahu, Hawaii 82, 175, 225, 261, 283

Oakland, CA (on San Francisco Bay) 281

Ocean Drilling Program (ODP) 45, 72

ocean sciences: 2, 7, 9, 12-13, 15-16, 22, 56, 58-59, 307, 455

ocean thermal energy conversion (OTEC) 32-35

Oceanapia sagittaria (burrowing sponge) 388

oceanic crust 64-65, 67, 69, 71-77, 80-81, 84-86, 89-91, 127, 134, 138, 280, 290, 458-461

oceanic plateaus 73-74, 134, 137

oceanic province 304-305, 320

oceanic ridges 64, 67, 70-71, 74-81, 83-86, 89-91, 97, 127-130, 133, 137, 139, 142, 199-200, 245, 260, 280, 290, 421-423, 425-426, 460-461

crests of 67, 81, 174

earthquakes on 65, 69, 77

sedimentation on 31, 128-129

transform faults in 73, 79-81, 85, 90-91, 260, 342

types of 77

volcanism in 78

oceanic upwelling 185

oceANS

aesthetic aspects of 25, 27, 31, 33-35, 428, 430, 432, 439-440, 450

assimilative capacity of 428-432, 441, 450, 452, 501

benthic environments in 303-305, 318, 320-321, 358, 431

climate zones of, 165-168, 175

color of 111

exploration of 16-18, 21, 24, 28, 34, 56-57, 323, 423, 452

formation of 5

foundations of life in 287

interactions of atmosphere and 5, 58, 145, 476

land-atmosphere interactions with, 165-168, 175

noise in 116

pelagic environments in 53-54, 59, 126, 135, 299-300,

303-305, 312, 318, 320-321, 356, 358, 364, 372, 378,

384-385, 388-390, 398-400, 418-419, 431, 444

pycnocline zone of 4, 183, 194-197, 206, 447, 457

recreational uses of 1, 15, 25, 29, 31, 34-35, 257, 270, 432

residence times in 33, 93, 98, 100, 117, 119, 122, 145, 147, 257, 280, 287, 302, 305, 320, 323-324, 332, 336-338,

349-350, 417, 427, 429-431, 437, 440, 444-445, 447, 450, 452, 455, 469-471

surface (mixed) zone of 3-4, 22, 40, 102, 109, 135, 161-162,

180-181, 183-186, 189-190, 192-193, 195-196, 198, 201,

204, 206, 211, 297, 303, 308, 320, 324-325, 328-336, 343,

345-346, 348-352, 356, 416-417, 445, 447, 457, 466, 495

surface height of 38, 41, 58-59, 183-184, 187-188, 219,

230-231, 239, 246-247, 254

surface microlayer of 48, 110, 356-357

octopi 287, 370, 374, 376, 385, 420

blue-ringed (*Hapalochlaena* sp.) 287, 376*Octopus luteus* 374*Odobenus rosmarus* (walrus) 316-318, 419

oil (petroleum) 22, 25, 28-29, 31, 34-36, 45, 85, 89, 101, 143, 281, 302, 304, 423, 434-435, 443, 450, 452

oil spills 2, 25, 338, 427, 434-435, 449-450

Okhotsk, Sea of K 199

Okushiri, Japan 229

Old Glory goby (*Amblygobius rainfordi*) 382

omnivores 290-291, 297, 305, 308-309, 319, 356, 358, 388

onshore-offshore transport 329

ooliths 130

oozes 21, 127, 134-137, 139, 141-142

diatomaceous 137

radiolarian 134-136, 142

operculum 376, 415

optimum concentration range, of toxins 500-502

orbicular (*Cyclichthys orbicularis*), 375orbicular burrfish (*Cyclichthys orbicularis*) 375

orbital motion 217, 219, 225-226, 232, 236, 271, 486

orbital velocity 131, 142, 245-246, 248, 254, 271-272, 481-485, 489-490

Orcinus orca (killer whale) 299, 315, 317, 411

Oregon (OR) 5, 73, 164, 167, 229, 302, 337, 339, 426, 448, 451

organic matter 4, 423

- organisms 4-5, 13, 53-54, 59, 93, 97, 101, 110, 120, 124-126, 139, 287-291, 295, 299, 303-305, 307, 311, 318-320, 336, 349, 351, 356-358, 370, 398, 412, 415, 420, 433-434, 440, 446, 494, 496, 500-502
 classification of 287
 microbial 291, 299, 307
Origin of Species (Darwin) 20
Orinoco River, Venezuela 159, 327
orthogonals (wave rays) 222-223, 233
oscillation(s)
 in standing waves 210, 212, 230-233, 246-252, 254-255
 ocean-atmosphere 26, 153, 160-165, 175, 189-190, 230, 301, 446
 tuned 192, 232, 247-249
oscillations 160, 163-164, 175, 232
osmoregulation 349-351, 383-384, 390-391, 398, 400, 431, 444, 450
osmosis 383-384, 399
osmotic pressure 379, 383
Ostracion meleagris (spotted boxfish) 375
OTEC (ocean thermal energy conversion) 32-35
otter trawls 53
outfalls 34, 429, 432, 434, 437, 450
overfishing 25-27, 312, 332, 340, 352, 428, 444, 451
overturning 109, 200, 206, 445, 448
oviparous species 385
ovoviviparous species 385
oxidation 137, 139, 289, 303, 428, 494
Oxycheilinus digramma (cheeklined wrasse) 379
Oxycirrhitus typus (longnose hawkfish) 408
oxygen 13, 65, 100-102, 148, 494-495
 demand 337-338
 depletion of 302, 337-339, 350, 352, 429-431, 435-436, 448-451
 in seawater 4, 49, 57, 99-102, 116, 128, 130, 139, 194, 197, 289-290, 297, 301-302, 320-321, 356, 429, 431, 446-448, 451
oysters 3, 5, 134, 282, 308, 311, 336, 349, 360-361, 385, 431, 441, 443, 447, 449, 451
 eastern (*Crassostrea virginica*), spiny 385, 443
ozone 124, 146-147, 176, 204, 293, 321, 471, 474
ozone layer, depletion of 124, 147, 176, 293
Pacific Decadal Oscillation (PDO) 164-165, 175
Pacific Ocean 5, 17-18, 20, 24-25, 27, 29, 66-67, 69-74, 82, 88-91, 115, 122-123, 127-130, 133, 136-137, 143, 157, 159-165, 167, 171, 175, 190-191, 196, 198, 201, 207, 214-215, 227, 229-230, 233, 240, 249, 266, 271, 296-297, 299, 302, 305, 309, 339, 390-391, 408, 433-434
Pacific Plate 71-72, 74-75, 80, 82-83, 89
Pacific salmon 390-391
Pagurus sp. (crab) 414
paints, antifouling 35, 440-441, 451-452
Palau 264, 266, 310, 370, 381, 408
Palm Beach, FL (north of Miami) 276
Pamlico Sound, NC 342
Panama 227, 255
Pangaea 69, 76, 85, 88-89, 260, 461
Papua New Guinea 17, 37, 93, 126, 229, 310, 312-314, 326, 333, 357-358, 360-361, 363-366, 369-370, 372, 374-375, 377-382, 388, 392, 396-397, 403, 407-408
parachute drogues 50, 464
Paracyathus stearnsii (brown cup coral) 410
Paraluteres prionurus (black-saddled mimic filefish) 372
paralytic shellfish poisoning (PSP) 336-337, 350
Parapercis hexophtalma (speckled sandperch) 382
parasites 27, 288, 372, 376, 392-393, 396, 400
parasitism 340, 392, 400
Pardachirus pavoninus (peacock sole) 370
Pardo, Arvid 23
parrotfish, black-headed (*Scarus gibbus*) 375
partial tides 244, 248
partially mixed estuaries 198, 343, 345-349, 351-352, 457
particulate matter 97, 260, 302-303, 348, 431
passive margins 85-86, 88-91, 263, 323, 342, 350
Patagonia 19, 122, 263
pathogens, also toxins, toxicity 432, 436, 450
PCBs 101, 429, 431, 433-434
PDO (Pacific Decadal Oscillation) 164-165, 175
PDRs (precision depth recorders) 41-42, 44
peacock sole (*Pardachirus pavoninus*) 370
pearlscale angelfish (*Centropyge vrolikii*) 372
pectoral fins 380-383, 399
peguin
 King penguin, *Aptenodytes patagonicus* 319
pelicans, brown (*Pelecanus occidentalis*) 319
pelvic fins 380, 383
penguins 147, 162, 305, 318-319, 352, 418-419
Pennatulacea (sea pens) 359-360, 376, 396, 406, 410
Pennsylvania (PA) 442
Pensacola, Fla. 239
Periclimenes 370, 396
P. amboinensis (crinoid shrimp) 370
P. cf. tosaensis 396
P. cf. venustus 396
P. colemani (Coleman's shrimp) 396
P. imperator (emperor shrimp) 396
P. soror (sea star shrimp) 396
periods
 of waves 209-210, 218, 222, 224, 232, 239, 269, 331
periwinkles, *Littorina sp.* 412, 415
Persian Gulf 31, 130
Peru 19, 23, 26, 160-163, 175, 187, 229, 327-328
Peru Current 187
petroleum 22, 25, 28-29, 31, 34-36, 45, 85, 89, 101, 143, 281, 302, 304, 423, 434-435, 443, 450, 452
petroleum hydrocarbons, 101, 434, 452
Pfiesteria piscicida 376, 378
pH 3, 49, 57, 103, 117, 127-128, 130, 412, 416, 422, 424, 447
Phalacrocorax auritus (double-crested cormorant) 319
pharmaceutical products, from marine organisms 25, 27, 29, 34-36, 376, 428
phase changes, of water 103-105, 116, 118
Philippine Plate 75
Philippines 18, 20, 23-24, 28, 31, 72, 75, 90, 124, 171, 229, 313, 326, 363-364, 372, 375, 382
Phoca vitulina (harbor seal) 316
Phoenicians 17
phosphates 99, 130, 139, 203, 294-295, 297, 312, 336, 496
phosphorite nodules and crusts 30-31, 47, 128, 130, 142
phosphorus 3-4, 31, 99-100, 104, 130, 189, 230, 289, 293-296, 319,

- 330, 334-336, 417, 436, 476, 494-496
 photic zone 290, 300, 337
 photophores 419-420
 photosynthesis 85, 111, 289, 430, 494
 phototrophy 6, 289-290, 292, 319-320
Physalia physalis (Portuguese man-of-war) 310-311, 359, 378, 385
 physical oceanography 47, 59, 343
 phytoplankton 58, 111-112, 147, 160, 189, 230, 292-294, 296-300, 302-303, 305-309, 319-321, 326, 330-332, 334-338, 340, 349-350, 356-358, 388, 405-406, 417, 430, 497
 piers 209, 233, 257, 279, 342, 432
 Pinatubo, Mount, Philippines 72, 124
 pinnipeds 316-318
 pipefish, ghost (*Solenostomus paradoxus*) 370
 pistol shrimp (*Synalpheus sp.*) 397
 piston corers 44-45
 plains, abyssal 65, 89, 132-133, 142-143, 303
 plankton 53, 111, 305-306, 315, 320, 332
 plankton nets 53
 plastics, pollution from 29, 48, 120, 429, 439-440, 444, 450
 plate boundaries 67, 69-71, 73-77, 79-82, 84-85, 90-91, 129, 260, 342
 convergent 71-76, 78, 85, 89-90, 97, 122, 227, 260, 342, 423
 divergent 71, 75-81, 83-86, 89-91, 127-130, 133, 137, 139, 260, 280, 421-423, 425, 460-461
 transform 73, 79-81, 85, 90-91, 260, 342
 plate tectonics 20, 63, 66-67, 84-85, 89-91, 98, 119, 138-139, 260, 287, 428, 458, 461, 463, 476, 480
 plateaus, oceanic 73-74, 134, 137
 plates, lithospheric (tectonic) 45, 64-67, 69, 71, 77, 79, 82-83, 85, 90-91, 97, 260-261, 443, 458-460, 480
 platinum 31, 100
Plectorhinchus celebicus (Celebes sweetlips) 372
Plectorhinchus goldmanni (Goldman's sweetlips) 383
 plume worms 422
 plutonium 441
Pocillopora sp. (hard coral) 333
 Point Lobos State Park, CA (near Monterey) 257
 polar bears 305, 419
 polar cells 152-153, 159, 175
 polar regions 151, 175, 417, 419, 424, 445
 Polaris 9
 polarity, of molecules 96, 104
 Pole Star 9
 pollution 2, 94, 120
 Polynesia 17-18, 34, 85
 Polynesians 17-19, 35
 polypoids (Anthozoa) 363
 polyps 333, 360-361, 363, 365, 370, 372, 378, 381, 408, 446
Pomacanthus navarchus (blue-girdled angelfish) 381
Pomacentrus moluccensis (lemon damselfish) 392
 porcelain crab (*Porcellanella triloba*) 396
Porcellanella triloba (porcelain crab) 396
 pore (interstitial) water 29, 139, 143, 290, 303, 366, 399, 424, 446
 porpoises 226, 316-317, 320
 Portland, OR 167
 Portuguese man-of-war (*Physalia physalis*) 310-311, 359, 378, 385
 Poseidonius 17, 35-36
 potassium 13, 98-100, 117
 potential energy 183, 185, 211-212, 223
 practical salinity units (PSU) 99, 108, 468
 precipitation
 atmospheric 103, 125, 145, 150-153, 159, 165-167, 169-170, 174-176, 296, 325, 416, 475, 480
 of salts 31, 99-100, 128-130, 137, 470
 precision depth recorders (PDRs) 41-42, 44
 predators 27, 252, 280, 308, 318, 349, 356, 368, 370, 372, 375-376, 378-379, 381, 383, 385, 388, 393, 396-400, 406, 411-412, 415, 420, 498
Premnas biaculeatus (spinecheek anemonefish) 377
 pressure
 atmospheric 7, 38-39, 107, 147-148, 152, 155-156, 161, 168-169, 172-173, 213, 227, 229-230
 gradient balanced by centripetal force 145, 168, 170, 179, 183-189, 191, 194, 205, 207, 209, 230, 455, 491-492
 high 85, 152, 181, 191, 305, 421-422
 hydrostatic 281
 low 153, 162, 168, 170, 181, 314, 420
 pressure gradients 151-152, 168, 170, 173, 176, 181, 183-189, 194, 205, 211-212, 219, 237-238, 246, 487-488, 490-493
 vapor 146, 148, 462, 491
 water density and 37, 49, 93, 106-107, 116, 119, 128, 179-180, 195-197, 203, 455, 457-458, 467
Priacanthus hamrur (crescent-tailed bigeye) 374
 primary production 293, 299, 497
 primary productivity 85
 prime meridian 9-10, 14
Primovula sp. (allied cowrie) 365
 Prince Edward Island, Canada 337
 Prince William Sound, AK 260, 434
Prochlorococcus sp. (photosynthetic cyanobacteria) 306
 production
 nutrient limited 294, 299, 321, 330, 332-334, 495
 primary 85, 126, 142, 289-293, 296, 299-302, 319-321, 327, 330, 332, 335, 339, 350, 356, 409, 424-425, 430, 444-445, 448, 451, 493, 495-497
 secondary 290-291
 profile, cross sectional 64, 161, 169, 172, 199, 376, 379
 profiling, seismic 45-46
 progressive waves 210-212, 230-233, 239, 248-249, 251-252, 254
 projections, map 9-12, 14, 16, 41, 308, 310, 368, 499
 prokaryotes 288, 493
 protein 25, 289, 352, 495, 497-498
 protists 288, 356
 protons 94, 96
Protopalythoa sp. (zooanthid) 363
Protoreaster nodosus (rhinoceros sea star) 407
 protozoa 299, 310
Protula magnifica (spiral fan worm) 364
Pseudanthias huchtkii (threadfin anthias) 380
Pseudosimnia sp. (egg cowrie) 396
 PSU (practical salinity units) 99, 108, 468
Pterapogon kauderni, Banggi cardinalfish 388
Pterocaesio lativittata (yellowstreak fusilier) 379
 pteropods 3, 126-127, 134, 142, 310, 320, 358, 447, 449, 451
 Ptolemy 17
 Puerto Rico 24, 89, 171, 407
 pufferfish 372
 Pu'u'oo, Hawaii 80
 Puget Sound, WA 29, 253, 342

- Pugettia producta* (northern kelp crab) 410
 purse seines 53
 pycnoclines, also haloclines, thermoclines 4-5, 162, 182-184, 188-190, 194-198, 205-207, 229-230, 233, 302, 321, 325-326, 350, 447-449, 455, 457-458
 pygmy seahorse (*Hippocampus bargibanti*) 370
Pyllodesmium undulatum 365
 Pyrgomatidae (barnacle) 361
 Pythagoras 17
 Pytheas 17
 quill-backed rockfish (*Sebastes maliger*) 410
 radiactivity 63, 93, 101, 119, 179, 321, 433, 441-443, 455, 468
 radiation
 electromagnetic 38, 51, 58-59, 94, 110-113, 117, 471-473
 of heat 149-151, 458, 471
 solar 244
 radio waves 38, 110-111
 radioactivity
 dating by decay of radioactive isotopes 138
 in tracing water masses 50, 203-204, 206-207, 441
 parent and daughter atoms 308, 391, 468-469
 radioisotopes 99, 101, 116-117, 203, 206, 441, 451
 radioisotopes (radionuclides) 64, 82, 99, 101, 116-117, 203, 206, 441, 451, 468-469
 radiolaria 126-127, 135-136, 139, 142, 288, 310, 320
 radiolarian oozes 134-136, 142
 raggy scorpionfish (*Scorpaenopsis venosa*), 370
 rain, rainfall, also precipitation, atmospheric 103, 125, 150-153, 159, 165-166, 174-175
 rainbow runner (*Elagatis bipinnulata*) 372
 Rainbow trout (*Oncorhynchus mykiss*) 383
 Raritan Bay, NJ 342
 rays
 blue-spotted (*Taeniura lymma*) 313
 manta (*Manta birostris*) 313, 315, 383, 396, 408
 torpedo (Torpedinidae) 313
 rebreather device, scuba 37
 recreation, oceans and 1, 15, 25, 29, 31, 34-35, 257, 270, 432
 recycling
 nutrients 295-296, 319, 335, 350
 of human products 432
 red (deep-sea) clays 127, 137, 142
 Red Sea 17, 21, 78-79, 89-90, 128-130, 137, 159, 313, 324, 346, 375, 378, 396, 470
 red tides 336-337
 red urchin (*Strongylocentrotus sp.*) 411
 red-cheeked fairy basslet, threadfin (*Pseudanthias huchtii*) 380
 redbreasted Maori wrasse (*Cheilinus fasciatus*) 381
 reef flats (terraces) 406-408, 424
 reef whitetip shark (*Triaenodon obesus*) 313, 315
 reefs
 atolls 20, 24, 32-33, 84-85, 89-90, 229, 233, 279-280, 282-283
 barrier 84-85, 264, 280, 282-283, 408
 fringing 84-85, 225, 264, 280, 283, 408
 reflection
 of light in water 111
 refraction
 of light in water 113
 of sound in water 113-116
 of waves 222-223, 229, 266
 refuse, trash and garbage 34-35, 120, 428, 434, 439-440, 450
 relationships, nonlinear 7, 13, 341, 475, 477-480
 relict sediments 134-135, 142-143, 261
 remora (*Echeneis naucrates*) 313, 382-383, 396
 remotely operated vehicles (ROVs) 29, 55-57, 78
 reproduction
 asexual 385, 399
 hermaphroditic 385, 399
 migration and 16, 54, 82, 154, 156, 262, 274, 277, 282, 297-298, 302, 309, 350, 383, 389-391, 418
 separate-sex 384
 timing in 388
 vegetative 385
 reservoirs, oil and gas 86, 89
 residence time 33, 93, 98, 100, 117, 119, 122, 145, 147, 257, 280, 287, 302, 305, 320, 323-324, 332, 336-338, 349-350, 417, 427, 429-431, 437, 440, 444-445, 447, 450, 452, 455, 469-471
 residual currents 345, 347, 349
 resources 1, 22-27, 30-31, 34-36, 340, 428
 respiration 3, 305, 497
 restoring forces, currents and, waves and 180, 211-212, 232-233
 resuspension, of sediments 119, 131, 145, 257, 280, 287, 326, 455, 464-465
 reversing thermometers 48-49
Rhincodon typus (whale shark) 313
 rhinoceros sea star (*Protoreaster nodosus*) 407
 Rhodophyta (red algae, Phylum) 326
Rhopalaea sp. (tunicate) 363
 rift zones, also specific zones 71, 76, 78-80, 85, 89, 260
 rings, Gulf Stream 192-193, 206
 Rio de Janeiro, Brazil 248
 Rio Grande Rise 82
 rip currents 2, 226, 232-233, 272
 rivers
 deltas of 5, 121, 134, 260, 263, 281-284, 341-342, 429-430
 erosion by 120
 oxygen depletion in 338, 431
 sediments transported by 120
 tidal currents in 250-251, 254-255
 roaring forties 153
 Robinson projection 11-12
 rockfishes
 copper (*Sebastes caurinus*) 410
 quill-backed (*Sebastes maliger*) 410
 rocky intertidal communities 304, 318, 403, 412-416, 424-425
 Rocky Mountains 88, 159
 Romania (Balkans) 76
 rose anemone (*Tealia lineata*) 410
 Ross, John 44
 Rossby waves 152, 230, 232
 rounded caudal fins 381
 ROV
 Argo 22, 56-57, 116
 ROVs (remotely operated vehicles) 29, 55-57, 78
 Royal Society 20
 runoff, freshwater 65, 94
 Russia 25, 76, 199, 390, 426, 441
 Ryukyu Trench 71
 Sabellidae (tube worms) 360

- saccopharynx fish 419
 Sacramento River, CA 345
 Sahara Desert 123-124
 Saint Lawrence River, Canada 201
 Sakhalin Island, Russia 452
 salinity 203, 468
 - and solubility of gases 101-102
 - as conservative property 203
 - electrical conductivity and, in estuaries 49, 57, 99, 116-117
 - ice formation and 109, 165, 197-198, 206, 332, 417, 424
 - in coastal oceans 324-325
 - in rocky intertidal communities 304, 318, 403, 412-416, 424-425
 - ocean surface 157, 165
 - of marginal seas 122, 159, 324-325
 - water density and 37, 63, 93, 119, 145, 179, 455, 457, 467
 salmon 3, 165, 349, 389-391, 431, 443
 - Pacific 390-391
 - salps 310-311, 320, 358-359, 363
 - salt marshes 85, 101, 260, 280, 290, 349
 - salt wedge estuaries 343, 345-348, 351
 - salts, dissolved, also salinity 98-99, 109-110, 116, 383
 Samoa 24
 samplers, sampling
 - bottles for 47-49, 54
 - contamination of 48
 - core 44-45
 - CTD 49, 99
 - grab 44-45, 54, 59-60
 - of marine organisms 53
 - of seafloor 20, 25, 44-47, 54, 59, 261, 278
 - of seawater chemistry 47-49, 54, 99
 - rosette 49
 San Andreas Fault, CA 73, 80, 91
 San Diego Bay, CA 346
 San Francisco Bay 30, 121, 249, 281-283, 342-343, 345, 347, 349, 429-430, 438-439, 443-444, 471
 San Francisco, CA 10, 30, 80, 121, 141, 174, 239, 249, 268, 281-283, 326, 342-343, 345, 347, 349, 414, 429-430, 438-439, 443-444, 471
 San Joaquin River, CA (near San Francisco) 345
 sand anemones 360, 368
 sand burrow 396
 sand dollars (*Clypeaster sp.*) 406-407
 sand dunes 259-260, 267-269, 273, 275
 Sand, oolite 130
 sandperches, speckled (*Parapercis hexophtalma*) 382
 Sandy Hook Bay, NJ 342
 Santa Barbara Harbor 278-279
 Santa Cruz Mountains 80
 Santa Cruz, CA (between San Francisco and Monterey) 80, 260
 Santa Monica 279, 438
 sardines 298-299, 312, 496
 Sargasso Sea 192-193, 301, 307-308, 349, 390-391, 416-417, 424-425
 Sargassum sp. 301, 307, 416-417, 424-425
 sargassumfish (*Histrio histrio*) 416
 Saronikos Gulf, Greece (central Aegean Sea) 339
 satellites 18, 21-22, 30, 37-39, 41, 43-44, 57-60, 84, 87, 94, 111, 115, 123-124, 146, 163-164, 170-171, 176, 184-185, 192-193, 206, 215, 221, 230, 248, 252, 255, 263, 278-279, 300-301, 327-328, 331, 342, 347, 444, 462
 saturation pressure 147-148, 175
 saturation solubility 101-102, 117, 301, 431
 Saudi Arabia (Arabian Peninsula) 31
 saw blade shrimp (*Tozeuma armatum*) 396
 scale worms 396, 422
 scallops 360, 376
 Scandinavia 88, 167, 263
 scarps 268-269, 282
Scarus gibbus (black-headed parrotfish) 375
 scattering, of light in water 111
 scavengers 313, 415-416, 421, 424
 scavenging 358
 schooling 308, 312, 378-379, 398-399
 scientific (exponential) notation 6, 12, 14
Scorpaenopsis macrochir (flasher scorpionfish) 392
Scorpaenopsis venosa (raggy scorpionfish) 370
 scorpionfishes 370, 376, 381, 384
 - flasher (*Scorpaenopsis macrochir*) 392
 - raggy (*Scorpaenopsis venosa*) 370
 Scotch Cap, AK 227
 Scotland 198
 scuba divers 1, 21, 27, 31, 37, 54-55, 59, 111, 113, 116, 209, 217-218, 315, 382-384, 392, 398, 408
 Sea Beam multibeam sonar 42
 sea cucumbers 311, 359-360, 364, 376, 388, 396, 406-407, 416, 420, 498
 - creeping (*Cucumaria sp.*) 364
 - Thelenota rubralineata* 388
 sea fans (gorgonians) 363, 365, 370, 378, 396, 404, 408
 sea fans gorgonians
 - Melithaea sp.* 363
 sea grasses, turtle grass (*Thalassia sp.*) 365-366, 370
 sea lion, California (*Zalophus californianus*) 27, 316-317, 320, 337, 411, 433, 438
 Sea of Japan 339, 441, 451
 Sea of Okhotsk 199
 sea otter (*Enhydra lutris*) 318, 411-412, 424
 sea pens (Pennatulaceae) 359-360, 376, 396, 406, 410
 sea snakes
 - banded (*Laticauda colubrine*) 317
 sea stars 308, 311, 357, 360, 364, 370, 385, 392, 396, 403, 406-407, 410-411, 415-416
 - basket star 364
 - Linckia laevigata* 392
 - rhinoceros (*Protoreaster nodosus*) 407
 - sea star shrimp (*Periclimenes soror*) 396
 sea turtles 252, 317-318, 320, 365-366, 391, 398
 - green (*Chelonia mydas*) 317, 365-366
 - hawksbill (*Eretmochelys imbricata*) 317-318
 sea urchins 311, 365-367, 374, 376, 396-397, 403, 406-407, 411-412, 416, 424-425, 447, 498
 - Astropyga radiata* 397, 407
 - Echinocardium sp.* (heart urchin) 367
 - fire (*Asthenosoma intermedium*) 374
 - fire (*Asthenosoma varium*) 396
 - heart (*Echinocardium sp.*) 367
 - long-spined (*Diadema savignyi*) 365
 - red (*Strongylocentrotus sp.*) 411

- sea-level change 3, 7-8, 13, 25, 32, 38, 58, 63, 65, 79, 82, 84-88, 90-91, 119-121, 131, 135, 139-140, 142, 151-152, 155, 161-162, 171, 227, 229, 235, 255, 257, 260-264, 269, 271, 275-277, 280-284, 341-342, 350, 405, 419, 427, 445-446, 449, 451, 455, 458, 460-463, 472, 475
 eustatic 86, 88, 90-91, 261-263, 458, 460-461
 isostatic 82, 85, 88, 90-91, 261-264, 277, 458, 460-462
 seabirds 18, 162, 318-319, 329, 340, 383, 411, 450
 seafloor 29, 31, 38-46, 56-57, 59-60, 77, 82, 119, 125-126, 137, 139, 182, 200, 206, 221-224, 227, 232, 249, 272, 292, 303-304, 312, 318, 325-326, 331, 356, 364, 372, 381, 409, 420-421, 423, 438, 444, 459, 461, 464-465
 as habitat 53, 299, 303-305, 311, 318, 320-321, 324, 326, 338, 350, 356, 359, 364-365, 385, 398-400, 430-431, 438-439, 450
 depth of, bathymetry 39, 44, 58
 drilling of 22, 28-29, 31, 35, 45, 59, 66, 72, 131, 138, 143, 230, 452
 interaction of waves and, 33, 110, 116-117, 159, 209-211, 213, 217, 223-228, 233, 250, 253, 264, 268-270, 278-279, 283-284, 304, 412
 sampling of, 20, 25, 44-47, 54, 59, 261, 278
 slope of 28-29, 35, 65, 88, 130-133, 137, 141-143, 200, 423, 439
 spreading of 45, 64, 67, 70-71, 74-81, 83-86, 89-91, 97, 127-130, 133, 137, 139, 142, 199-200, 245, 260, 280, 290, 421-423, 425-426, 460-461
 topography of 39, 41-44, 58-59, 227, 309
 seagrass filefish (*Acreichthys tomentosus*) 366
 seagulls 318-319
 seahorses 370, 383, 385
 pygmy (*Hippocampus bargibanti*) 370
 spotted (*Hippocampus kuda*) 370
 seal
Arctocephalus gazella, Fur seal 27, 352, 418, 439
 Crabeater, *Lobodon carcinophagus* 418
 elephant (*Mirounga angustirostris*) 27, 316-317, 433
 harbor (*Phoca vitulina*) 316, 411
 seals 26, 147, 298, 316-318, 320, 352, 411, 418-419
 seamounts 43-44, 81-85, 89-90, 130, 134, 137, 200, 304, 331
 Seasat satellite 43
 seasonal variation
 in beaches 273
 in climate 153, 160, 255, 296, 301, 330, 332, 335
 in coastal oceans, 332, 350-351
 in primary production 332, 334-335, 350-351
 seawalls 225, 232, 276-278, 282-284
 seawater 93, 102
 composition of 99-103
 density of 99, 106-108, 116, 145, 184, 194, 467-468
 dissolved organic matter in 101, 291, 295, 303, 320, 330, 357, 450, 476
 nutrients in 5, 33-34, 57, 96, 99, 104, 106, 130, 139, 183, 189-190, 206, 230, 281, 289, 293-297, 299, 301-302, 319, 327, 329, 331-332, 335-336, 349-350, 405, 417, 422, 476, 495
 oxygen in 5, 290, 302, 337-339, 350, 352, 429-430, 435-436, 448-451
 pH of 3, 49, 57, 103, 117, 127-128, 130, 412, 416, 422, 424, 447
 trace elements in 99, 101, 116, 294
 upwelling of 126, 160-161, 173-174, 190, 206, 294, 299-300, 327-331, 334, 339, 349-351
Sebastes caurinus (copper rockfish) 410
Sebastes maliger (quill-backed rockfish) 410
 secondary production 290-291
 sediment 5, 16, 20, 29, 31, 33, 38-40, 44-47, 53-56, 58-60, 65, 72-73, 75, 84-86, 88-91, 97-98, 101, 111, 117, 119-128, 130-143, 171, 201, 260-261, 263, 267-268, 272, 274-276, 280-282, 290, 292, 296, 303-305, 310, 318, 320, 326, 334, 341-342, 347-348, 355-357, 359, 365-367, 378, 391, 398-400, 404, 406, 420-421, 424, 428-433, 438-439, 441, 444, 450, 459-460, 464-466, 470-471, 502
 accumulation rates of 130, 133-134, 136, 142
 age dating of 138
 as habitat 29, 53, 299, 303-305, 311, 318, 320, 324, 350, 356, 359, 438-439, 450
 as historical (stratigraphic) record 45, 63, 72, 93, 119, 138, 179, 455, 468-469
 biogenous 120, 124-128, 130-131, 133-135, 137-139, 141-142
 biogeochemical cycles and 97-98, 101, 116-117, 119-120, 128, 296, 302, 307, 434, 441, 470
 classification of 120, 142
 coastal formation by 257, 260, 282
 cohesiveness of 131, 464-465
 cosmogenous 120, 131, 134, 142
 graded beds in 127, 131-134, 141-143
 hydrogenous 120, 128, 130-132, 134, 142
 ice rafted 137
 in back-arc basins 75, 90
 in continental margins 85, 134-135, 142-143, 261
 in estuaries 346
 lithogenous (terrigenous) 86, 120-124, 127-128, 130-131, 133-137, 142, 294, 303, 336
 relict 134-135, 142-143, 261
 resuspension of 119, 131, 145, 257, 280, 287, 326, 455, 464-465
 sampling of 44-47, 54, 59, 261
 settling velocity of 465
 sorting 120, 134, 220-221, 232, 271, 273, 282, 456, 466
 suspended 47, 58-59, 86, 111, 117, 121, 123, 128, 132, 139, 179, 280-281, 292, 304, 326, 334, 347-348, 404, 406, 429-431, 433, 438, 444, 450, 464-466
 thickness of 130, 133-134, 142
 topographic smoothing by 84
 transport of 33, 35, 120, 123-124, 131-133, 137, 141-142, 213, 260-261, 273, 420, 428, 431-432, 464, 466
 sedimentary arcs 74, 89-90, 97, 260
 sedimentary mud 20, 35, 38, 40, 43-44, 120-121, 133, 135-137, 280-281, 303-304, 318, 366, 372, 375, 431, 466
 sedimentary rocks 5, 71, 73, 76, 97, 120, 123, 128, 138, 140, 143, 264
 sediments, relict 134-135, 142-143, 261
 seiches 230
 seismic profiling 45-46
 seismic tomography 66
 selenium 100, 104
 Sellafield, Great Britain 441
 semidiurnal tides 239-249, 252, 254-255
 sensible heat 104, 106, 117, 150, 172

- Sepia latimanus* (broadclub cuttlefish) 314
Sepioteuthis lessoniana (common reef squid) 314, 388
 Serbia (Balkans) 76
 sergeant fish (*Abudefduf sp.*) 379, 388
 setae 357
 settling velocity, of sediments 465
 sewage 336, 338, 429-430, 432, 434-436, 450, 452
 Seychelle Islands 25
 shadow zone 114-115
 shallow-water waves 222, 224, 227-228, 232, 245-247, 250, 254-255
 sharks 27, 313-315, 381, 398
 gray reef (*Carcharhinus amblyrhynchos*) 313, 315, 381
 great white (*Carcharodon carcharias*) 27, 313, 315
 nurse (*Nebrius concolor*) 313, 315
 reef whitetip (*Triaenodon obesus*) 313, 315
 whale (*Rhincodon typus*) 313, 315
 shear stress, also friction 213, 230
 shelf break 65, 304, 320, 323
 shelf valleys 88
 shellfish 3, 15, 25, 33, 280, 316, 318, 334, 336-338, 349-350, 431-432, 437, 439, 444, 450-451
 Shemya Island 411
 Sheridan, WY 167
 ships, shipping 52, 120, 215, 323
 shoals 19, 332, 347
 shore 209, 222-225, 232, 264, 412, 415-416
 shrimp 27, 357-358, 370, 372, 374, 376, 396-398, 416, 422
 Allopontonia sp. 370, 396
 banded coral (*Stenopus hispidus*) 357
 Coleman's (*Periclimenes colemani*) 396
 coral (*Dasykaris zanzibarica*) 370
 coral (*Vir philippinensis*) 396
 crinoid (*Periclimenes amboinensis*) 370
 emperor (*Periclimenes imperator*) 396
 harlequin (*Hymenocera elegans*) 357
 humpbacked (*Hippolyte commensalis*) 396
 Periclimenes cf. tosaensis 396
 Periclimenes cf. venustus 396
 pistol (*Synalpheus sp.*) 397
 saw blade (*Tozeuma armatum*), sea star (*Periclimenes soror*), tiger pistol (*Alpheus bellulus*) 396
 urchin (*Gnathophylloides mineri*) 396
 SI units 12, 14, 104
 Siberia, Russia 88
 Sierra Nevada mountains 121, 159, 174
 silica, silicates 73, 97, 125-126, 131, 139, 143, 269, 294-297, 307-308, 310, 319-320, 330, 334-336, 350, 417, 422, 425
 siliceous organisms 125-126, 135
 silicon 65, 94, 100-101, 120, 293, 296, 335
 sills 77, 131, 197-198, 262-263, 342, 345-346, 351
 silt 40, 120, 137, 142, 266, 465
 silver 31, 100, 128, 139, 372, 390, 422
 sinks 4, 67, 71, 84-85, 109, 152, 194, 197-199, 280-281, 293, 348, 456-458, 460, 464
 skates 385
 slack water 249-252, 254
 slope
 of beaches 270, 273-274, 282
 of ocean surfaces 184-185
 of seafloor 28-29, 35, 65, 88, 130-133, 137, 141-143, 200, 423, 439
 Slovenia (Balkans) 76
 slumps 124, 212, 227, 229, 261, 265-266
 slurp guns 54
 slurries 34-35, 435
 snails 310-311, 358, 375, 388, 392, 400, 403, 411-412, 414-416, 422, 424, 447
 black turban (*Tegula funebralis*) 414
 Epitonium billeeanum 388
 mud (*Nassarius papillosus*) 375
 parasitic (*Thyca crystallina*) 392
 sodium 13, 95, 97-100, 117, 130, 470
 sodium chloride 13, 97, 130
 soft corals 361, 363, 370, 372, 396, 403, 408, 424
 solar energy 123, 150-151, 166, 173, 175, 405, 466, 471-472, 474
 sole, peacock (*Pardachirus pavoninus*) 370
 Solomon Islands 312, 372, 379
 solstices 150, 153, 155, 176
 solubility, also saturation solubility 101-102, 117, 127, 130, 139, 142, 301, 431, 433, 447-448, 451
 Somalia 23, 228
 sonar 41-45, 54-55, 78, 113-117, 261, 443, 451
 sorting, in sedimentation 270-271
 sound channels 113-116
 sound, underwater transmission of 52, 113-115, 117
 sounders 41-43, 59, 309
 soundings, difficulties of, echo 18, 20, 39-40, 42-44, 113, 117
 South Africa 16, 193, 248
 South America 12, 14, 19-20, 22, 69, 71, 73, 77, 89, 121, 137, 159, 163, 167, 174, 186, 199, 305, 327
 South Carolina 170
 South China Sea 24-25, 31, 90, 122
 South Equatorial Current 186
 South Pole 9-10, 14, 138, 147, 152, 481-482, 487-488
 South Sandwich Trench 89
 Southern Ocean 137, 147, 198-199, 296, 300, 333, 352, 418, 426, 445
 Soviet Union 23, 45, 204, 441-442, 451
 Spain 17
Spartina sp. (marsh grass) 365-366
 Spawning 252, 335, 349, 379, 384-385, 388-391, 399-400, 444
 species
 classification of 287, 404, 424
 endangered 25, 31, 34-35
 nonindigenous 427, 431, 443, 451
 species succession 334-335, 350
 speckled sandperch (*Parapercis hexophtalma*) 382
 spectrum
 absorption 473
 emission 473
 speed
 in hunting and defense 368
 of waves 210-211, 218-219, 221-222, 232, 245-246
Sphyraena putnamiae (chevron barracuda) 379
 spinecheek anemonefish (*Premnas biaculeatus*) 377
 spines 110, 293, 356, 368, 372, 375-376, 381-382, 396-397, 399
 spiny oyster 360-361
 Pacific (*Spondylus varians*) 361
 spiral, Ekman 181-182, 205, 207

- Spirobranchus giganteus* (Christmas tree worm) 364, 368, 376
 spits 265, 274-275, 278-279, 341-342
 Spitsbergen 88
Spondylus varians (Pacific spiny oyster) 361
 sponges 6, 13, 27, 318, 365, 370, 372, 376, 378, 385, 388, 396, 399-400, 403, 416
 burrowing (*Oceanapia sagittaria*) 388
 spores 331, 350, 409, 411, 417, 424
 spotted seahorse (*Hippocampus kuda*) 370
 Spratly Islands 24-25
 spreading cycles 69, 76, 86, 88, 91, 262, 305, 461
 spreading, seafloor 45, 67, 77, 97, 461
 spring tides 241-244, 252-255, 269, 384, 389, 406, 415
 squid 315-316, 368, 418
 common reef (*Sepioteuthis lessoniana*) 314, 388
 Sri Lanka 228
 St. Helens, Mount, OR 72-73, 124
 stacks 266
 staghorn coral (*Acropora sp.*) 363
 standing stock, see also biomass 300, 334, 498
 standing waves 210, 212, 230-233, 246, 248-252, 254
 steady state 6, 98, 116-119, 470
 steepness, of waves 210-211, 213, 215, 217, 221-224, 232, 269, 491-493
 steering forces, currents and 180-181
Stenopus hispidus (banded coral shrimp) 357
Stichodactyla haddoni (Haddon's sea anemone) 377
 stonefishes 376, 381
 stratigraphy 138
 stratosphere 146-147
 striated frogfish (*Antennarius striatus*) 369
 striped bass 26, 349-350, 443
Strongylocentrotus sp. (red urchin) 411
 strontium 100
 sturgeon 443
 subduction zones 67, 69-76, 78, 81, 85-86, 89-90, 97, 121-122, 127, 133, 227, 229, 290, 342, 421-424
 sublittoral zone 304, 320
 submarine canyons 43, 88, 124, 133, 260, 271, 282
 submarines 21, 28-29, 35, 38, 41, 43, 55-56, 88, 111, 113-116, 124, 132-133, 230, 260, 271, 282, 378-379, 383, 405, 441-442, 451
 submersibles 21, 38, 43, 47, 54-57, 59-60, 78, 419, 421
 subpolar (high-latitude) gyres 181, 185
 subtropical gyres 157, 181, 185-189, 191, 193, 207, 296, 301, 320, 390, 416, 440
 Suez Canal, Egypt 470
 Sulawesi, Indonesia 229
 sulfides 6, 31, 103, 128, 139, 162, 289-290, 302, 320, 338, 346, 351, 356, 421-423, 425, 429, 431, 435
 sulfur 31, 98-100, 102-104, 140-141, 289, 293
 Sumatra, Indonesia 75, 227-229
 superplumes 67, 76, 79, 81
 supersaturation 127, 148, 175, 302, 320
 supralittoral zone 33, 304, 412, 415, 424
 surf, surf zone 31, 33, 209, 211, 224-227, 253, 268-269, 278-279, 283-284
 surface sediments 44, 127, 135-137, 139, 142-143, 290, 399, 420
 surface tension 96, 109-110, 116-117, 180, 211-212, 232-233, 357
 surface, ocean microlayer of 48, 110, 356-357
 sloping of 184-185
 surfers 211, 220, 224-225, 250
 surgeonfish, mimic (*Acanthurus pyroferus*) 372
 surges from 170-172, 227, 232, 273, 280-281, 283, 304, 412, 446
 survival niches 404, 424
 suspension feeders 357-360, 363-364, 398-400, 406, 415, 420
 benthic 359
 pelagic 358
 suspension, of sediment 359-360, 464
 swamps, mangrove 2, 101, 259-260, 280, 403, 431, 450
 swash 270-271, 274
 sweetlips 372, 383
 Celebes (*Plectorhinchus celebicus*) 372
 Goldman's (*Plectorhinchus goldmanni*) 383
 swells 67, 213, 217, 221, 232-233, 324, 376
 swim bladders 116, 314, 320, 381, 384, 398-399
 swimming, adaptations in 379-380
 swordfish 312, 381
 symbiosis 392, 400
Synalpheus sp. (pistol shrimp) 397
Synchiropus splendidus (mandarinfish) 388
Synodus binotatus (twospot lizardfish) 369
 synoptic observation 58, 192
 Syria 17, 176
Taeniura lymma (blue-spotted ray) 313
 Tahiti 19
 Taiwan 17, 24, 31
 Tambora, Indonesia 75, 124
 Tampa Bay, FL 444
 taxonomy 288
Tealia lineata (rose anemone) 410
 tectonic estuaries 341-342, 350
 tectonic plates, lithospheric 64, 67, 69, 79, 82, 90, 458-459
Tegula funebralis (black turban snails) 414
 tektites 141-142
Tellina sp. (clam) 366
 temperature and carbon dioxide solubility in seawater 127
 and solubility of gases 102, 448, 451
 as conservative property 203, 206
 diurnal cycles in 165, 173
 greenhouse effect and 3, 15, 102-103, 106, 146, 150, 179, 216, 461
 in coastal oceans 325
 in rocky intertidal communities 33, 304, 318, 403, 412-416, 424-425
 land and sea breezes and 165, 173-174, 176
 ocean surface 58, 147, 156, 165-166, 168, 192, 216
 water density and 37, 49, 93, 99, 106-109, 116, 119, 145, 179, 183-184, 190, 194-195, 197, 205-206, 211, 297, 323, 455, 457-458, 462, 467-468
 temporal variation 47, 58, 101, 115-116, 118, 168, 249, 308, 472
 teratogens 433, 450, 501, 503
 terrace, low-tide 269
 terranes, exotic 73-74, 89, 97
 terrestrial climate zones 166-168
 terrigenous (lithogenous) sediment 86, 120-124, 127-128, 130-131, 133-137, 142, 294, 303, 336
 territorial seas 22-24, 34

- Texas (TX) 28, 133, 171, 239, 259, 262, 276, 339, 346
 Thailand 31, 163, 228
Thalassia sp. (turtle grass) 365-366, 370
Thalassoma lunare (moon wrasse) 382
 Tharp, Marie 21, 42, 58, 60
Thelenota rubralineata (sea cucumber) 388
 thermoclines 183, 190, 195, 197, 297-302, 325, 327, 329-332, 334-335, 337-338, 350
 seasonal 183, 195, 197, 325, 331-332, 334-335, 337, 350
 thermohaline circulation 180, 194, 205-207, 230, 445-446
 thermometers 48-49, 115
 reversing 48-49
 thermometry, acoustic 115-116
 threadfin anthias (*Pseudanthias huchtii*) 380
 Three Mile Island, PA 442
 Thresher USS 230
Thunnus sp. (tuna) 378
Thyca crystallina (parasitic snail) 392
 tidal bores 250, 254-255, 268, 318
 tidal curves 239
 tidal ranges 235, 239, 241-242, 244, 247, 249-250, 252-255, 267
 tide pools 326, 376, 384, 412, 416, 424
 tides
 amphidromic systems and 246-248, 254-255
 and gravity 238, 254
 as waves 212-213, 239, 245-246, 249, 254
 characteristics of 239
 Coriolis effect and 246
 currents and 33, 194, 200, 206, 235, 248-255, 326, 332, 342-343, 345-346, 348-349, 351, 423, 439
 distribution of force in, 238, 254
 diurnal 239-243, 249, 254
 ebb 235, 249, 251-252, 254-255, 326, 345
 energy from, equilibrium 35, 253, 255
 flood 251, 255
 high 209, 235, 239, 241, 243-244, 246, 248-250, 252-253, 267, 269, 282, 304, 389, 412, 424
 landmasses and 245
 low 209, 235, 239, 241, 243-244, 246, 249-250, 254-255, 263, 268-269, 280, 356, 359, 406, 412, 416
 marine organisms affected by 252-253, 388-389
 mixed 239-243, 248-249, 254-255, 389
 neaptides 241-244, 254-255, 389
 nutrient transport by 331
 open-ocean 248-249, 254
 partial 244, 248
 predicting 244
 range of 33, 235, 239, 241-244, 246-247, 249-250, 252-255, 259, 266-267, 269, 341, 345, 389, 415
 tables for 239, 250-252, 255
 wave speed of 245-246
 Tierra del Fuego 19
 tiger pistol shrimp (*Alpheus bellulus*) 397
 timing, in reproduction 388
 Titanic 41, 56-57
 Tokyo, Japan 10, 207
 tomato anemonefish (*Amphiprion frenatus*) 377
 tomography 52, 66-67
 acoustic 52
 computer 67
 seismic 66
Tonicella lineata (lined chiton) 414
 TOPEX/Poseidon satellite 57, 215
 topographic maps 7-8
 topography, dynamic 184-185
 toxicity 433
 chronic 500
 dinoflagellate 336-337, 350, 352
 effects on marine organisms of 433, 450, 452, 501-502
 in estuaries 349, 500
 in hunting and defense 376
 in industrial waste 103, 431, 436-438, 450
 non point sources (urban and agricultural) 436, 450
 of antifouling paints 35, 440-441, 451-452
 synthetic vs. natural 434, 500
 toxins 287, 311, 336-337, 350, 376, 378, 432, 434, 502
Tozeuma armatum (saw blade shrimp) 396
 trace elements
 importance to life of, 39, 48, 60, 99, 101, 203, 294, 330, 431, 433-434, 436, 452, 502
 in seawater 99, 101, 116, 294
 tracers, in water masses 50, 203-207, 441
 tracing 50, 113, 201, 203-207, 441
 trade winds 152-154, 156, 159, 161-162, 166, 170, 174-177, 185-190, 205, 214, 329
 trains, wave 218-220, 232-233
 transform faults 73, 79-81, 85, 90-91, 260, 342
 transport
 Ekman 182-191, 194, 205-207, 269, 327-329, 345, 350, 440
 of heat latitudinally by ocean currents 151
 of nutrients 296
 of sediment 25, 33, 88, 120, 123, 131, 142, 172, 225, 260, 265-267, 277-278, 282, 428, 431-432
 onshore-offshore 329
 traps 53-54, 59, 81, 85, 141-142, 271, 314, 376, 439
 trash, pollution from, 34-35, 120, 428, 434, 439-440, 450
 trawl nets 20, 27, 29, 53-54, 59, 444
 trenches 67, 69-71, 73, 80, 89, 122, 137, 142, 245, 303, 305
 trevally 372, 379, 381
 bluefin (*Caranx melampygus*) 372
 Carangoides sp. 379, 381
 rainbow runner (*Elagatis bipinnulata*) 372
Triaenodon obesus (reef whitetip shark) 313
 tributyltin 433, 441, 451
Trichechus manatus (manatee) 365
Tridacna gigas (giant clam) 396-398
 Trieste bathyscaphe 56
 triggerfishes 376, 380-382
 clown (*Balistoides conspicillum*) 382
 triple junctions 71
 Tristan da Cunha 82
 tritium 203-204, 441
 trochoidal shape, of waves 210, 213
 trophic efficiency 298, 339-340, 350, 497
 trophic levels 298-300, 303, 310, 319, 339-340, 434, 450, 496-498, 502
 Tropic of Cancer 153
 Tropic of Capricorn 153
 tropical regions 333, 431, 466
 troposphere 146-147, 149, 151-153, 163, 175

- troughs, of waves 31, 210-213, 217, 219, 224, 226-228, 230, 232, 246, 249-250, 267, 269, 271-273
- Trout, rainbow (*Oncorhynchus mykiss*) 383
- Truman Proclamation 22
- Truman, Harry S. 22, 34
- truncate caudal fins 380-381, 399
- TS diagrams 202-203
- tsunamis 1-2, 35, 74-75, 133, 141, 209, 212-213, 223, 226-229, 232-233, 261, 304, 441-443
- Tubastrea* sp. (hard coral) 363
- tube worms
- Riftia pachyptila* 422-423
 - Sabellidae 360
- tuna 27, 298-299, 312, 340, 378-379, 381, 384, 496-498
- dogtooth (*Gymnosarda unicolor*) 312
 - Thunnus* sp. 378
- tuned oscillation 232
- tunicates 311, 359-360, 363, 365, 376, 399, 403
- Botryllus* sp. 363
 - Didemnum molle* 363
 - lightbulb, (*Clavelina* sp.) 363, 473
 - Rhopalaea* sp. 363
- turbidites, turbidite layers 127, 131-134, 141-143
- turbidity 226
- turbidity currents 35, 124, 132-133, 137, 141-142, 213, 260-261, 420, 464, 466
- Turbulence 121, 213, 326, 331, 343, 412, 415-416
- Turkey 76, 340-341
- Turnagain Arm, Cook Inlet, AK 250, 259
- turtle grass (*Thalassia*) 318, 365-366, 370
- turtles 27, 54, 252, 317-318, 320, 365-366, 370, 391, 398, 408, 439
- green (*Chelonia mydas*) 317, 365-366
 - hawksbill (*Eretmochelys imbricata*) 317-318
- Tuscarora, USS 40
- twospot lizardfish (*Synodus binotatus*) 369
- typhoons 171
- United Kingdom 45, 221, 441
- United Nations 22-23, 26, 34, 428
- United States 2, 22-26, 28-29, 31, 34-35, 40, 42-43, 45, 88, 91, 104, 122, 134, 143, 152, 163-164, 171, 173-174, 176-177, 229, 241, 257, 259, 262, 271, 274, 276, 280-281, 284, 292, 324, 337, 339, 342, 349, 376, 429, 432, 434-438, 443-444, 448, 452, 462, 475, 477
- units of measurement 6, 12, 14, 22, 31, 98-99, 147, 239, 468
- Upeneus tragula* (blackstriped goatfish) 367
- upwelling 67, 76, 136, 157, 159-162, 175, 185, 187, 189-191, 200, 205-207, 299-301, 319, 327-332, 339-340, 349-351, 417, 462-464
- coastal 126, 160-161, 173-174, 190, 206, 294, 299-300, 327-331, 334, 339, 349-351
- Ural Mountains, Russia 76
- urchin shrimp (*Gnathophylloides mineri*) 396
- Urechis caupo* (innkeeper worm) 366-367
- Valdez, AK 434
- valleys, in continental shelves 88
- van der Waals force 96-97, 103, 106, 110, 117
- Vanuatu 379, 383, 388, 396
- vaporization, latent heat of 96, 104-106, 116-118, 148, 150-151, 175, 466-467
- Vasco da Gama 18
- vectors 481
- vegetation 7, 149, 166, 264, 267-268, 275, 280, 282, 317, 323, 408, 444, 474
- vegetative reproduction 385
- velocity, of sound in water 52, 113-115, 117
- venom 376, 381, 399
- Venus 44, 94, 111
- vertebrates 288, 311-312, 336-337, 350, 383-384, 447
- vertical exaggeration 8-9, 14
- vertical movement of 180, 194, 205-207, 230, 445-446
- Vietnam 24, 31
- Vikings 18
- viperfish 419
- Vir philippinensis* (coral shrimp) 396
- Virgin Islands, U.S. 24, 34
- Virginia (VA) 239, 259, 279
- viruses 53-54, 288, 291, 303, 305-307, 320, 337, 376, 432
- viscosity 109-110, 116-117, 207, 216-217, 232, 293, 357, 388, 464
- viviparous species 388, 412
- volcanic islands 74-75, 82, 84-85, 89-90, 229, 260-261, 269, 280, 425
- volcanic rocks 45, 47, 66, 82, 124, 133, 264, 270, 421
- volcanoes, volcanism 2, 63, 71-82, 84-85, 89-91, 97, 101-103, 123-124, 129, 175, 227, 229, 260-261, 270, 280, 282, 290, 421, 425, 460
- as source of lithogenous particles 123
 - coastal formation by 67, 69-76, 78, 81, 84-86, 89-90, 97, 121-122, 127, 133, 227, 229, 260, 290, 342, 421-424
 - extinctions and 140-142, 229
 - in hot spots 66-67, 70, 81-84, 89-90, 129, 260-261, 280, 460
 - in magmatic arcs 74-75, 84, 89-90, 260
 - in oceanic ridges 64, 67, 70-71, 74-81, 83-86, 89-91, 97, 127-130, 133, 137, 139, 142, 199-200, 245, 260, 280, 290, 421-423, 425-426, 460-461
 - in rift zones 71, 76, 78-80, 85, 89, 260
 - in subduction zones 67, 69-76, 78, 81, 85-86, 89-90, 97, 121-122, 127, 133, 227, 229, 290, 342, 421-424
 - sedimentary (stratigraphic) record of 137, 142
- walrus (*Odobenus rosmarus*) 316-318, 419
- waste
- industrial 25, 336, 427, 432, 434, 437
 - waste disposal 25, 34-35, 257, 323-324, 346, 349, 367, 427-428, 431-436, 438-440, 443, 452
 - waste, waste disposal 25, 34-35, 257, 323-324, 346, 349, 367, 427-428, 431-436, 438-440, 443, 452
- wastes
- nuclear 441-442
- water
- anomalous properties of 3, 78, 93-94, 96-97, 103-106, 109-110, 116-118, 146-151, 154, 156, 166, 170, 173, 175-176, 180, 211-212, 217, 232-233, 288, 357, 444, 446, 466-467, 475
 - as necessary for life 94
 - chemical properties of 99-103
 - density of 37, 49, 93, 99, 106-109, 116, 119, 145, 179, 183-184, 190, 194-195, 197, 205-206, 211, 297, 323, 455, 457-458, 462, 467-468
 - dissolving power of 94, 96-97, 116
 - Earth's budget of 148-150
 - fresh, freshwater 25, 31, 34-35, 39, 65, 84, 88-89, 94, 96,

- 102, 108-110, 117, 120, 150, 157, 159-160, 166, 175, 183, 190, 195, 198, 201, 203, 206, 250-251, 280-282, 318, 321, 323-325, 328, 331-333, 336-337, 341-343, 345-346, 348-351, 383-384, 390, 399-400, 406, 417, 431-433, 436, 443-444, 451
heat properties of 93, 96, 104-106, 109, 116-118, 146, 148-151, 154, 156, 166, 170, 173, 175-176, 217, 444, 466-467
molecules of 6, 94-97, 103-104, 106-111, 116-117, 139-140, 147-148, 180, 197, 203, 211-212, 216-217, 219, 221, 223, 383, 441, 464, 467, 491, 496
phases of 103-104, 116, 118
physical properties of 94, 103-104, 108-110, 113, 116-117, 468
pore (interstitial) 29, 139, 143, 290, 303, 366, 399, 424, 446
transmission of light in 110, 112, 117
transmission of sound in 52, 113-115, 117
water column
aphotic zone in 112, 290, 292-293, 297, 309, 356, 419-420, 425
compensation depth in 127-128, 137, 142, 207, 292-293, 303, 305, 319
Ekman spiral in 181-182, 205, 207
photic zone in 27, 31, 101, 112, 117, 127-128, 137, 207, 290, 292-306, 308-309, 316, 319-321, 325-327, 331-337, 350-351, 356, 359, 364, 372, 390, 399, 403-405, 417, 419-420, 422, 424-425, 431, 447-448
stratification of 4-5, 162, 182-183, 188-190, 194-198, 205-207, 230, 302, 321, 325-326, 350, 447-449, 455, 457-458
wind-driven layer of 182-183, 185, 189
water masses
anoxic 128, 302, 320, 337-339, 346, 350-352, 366, 399, 423, 429-430, 435-436, 448-451
deep-ocean 184, 194, 197-198, 200-201, 203-204, 206-207, 297
water vapor 75, 94, 96, 103, 105-107, 139, 145-152, 167-168, 172, 174-176, 458, 462, 466-467, 473, 476, 491
wave rays (orthogonals) 222-223, 233
wavelengths 110-112, 114, 117, 150, 213, 220-221, 230, 232, 272, 472-473
of electromagnetic radiation 38, 58-59, 94, 110-113, 117, 149, 472-473
of heat energy 149-150
of oceanic waves 210, 212-213, 215, 219-221, 227, 229-233, 239, 245, 249, 251, 254, 332-334
tsunamis 1-2, 35, 74-75, 133, 141, 209, 212-213, 223, 226-229, 232-233, 261, 304, 441-444
waves
amplitude of 210
and Coriolis effect 230, 232
beach sand sorting by 271, 273
breaking 33, 110, 116-117, 159, 209-211, 213, 217, 223-227, 233, 250, 253, 264, 268-270, 278-279, 283-284, 304, 412
capillary 212-213, 216-217, 232
celerity (speed of) 210-211, 218-219, 221-222, 232, 245-246
coastal modification by 264, 266
complexity of 209, 232
creation of 212-215, 227, 229, 245, 332-334
crests of 67, 81, 174, 210-213, 215-217, 219, 222-228, 232, 246-250, 254, 271-273
currents and 215
deep-water 213, 217-218, 220, 222, 232-233
depth of no motion in 184-185, 218
dispersion of 213, 220-221, 232
dissipation of 216
energy from 213, 221, 259
energy of 211
erosion by 25, 88, 123, 172, 225, 265-267, 277-278, 282
frequency of 210
gravity 212-213, 232
heights of 58, 168, 209-217, 219-220, 222-224, 226-227, 229-230, 232-233, 239, 246, 252, 269, 272
horizontal pressure gradients in 212
interference 210, 219-220, 232
intermediate 222
internal 58, 200-201, 229-230, 233-235, 326, 331, 343, 345, 350
Kelvin 230, 232-233
movement of water in 211, 217, 221
nutrient transport by 331
periods of 209-210, 218, 222, 224, 232, 239, 269, 331
progressive 210-212, 230-233, 239, 248-249, 251-252, 254
refraction of 222-223, 229, 266
restoring forces in 180, 211-212
Rossby 152, 230, 232
shallow-water 222, 224, 227-228, 232, 245-247, 250, 254-255
speed (celerity) of 210-211, 218-219, 221-222, 232, 245-246
standing 210, 212, 230-233, 246, 248-252, 254
steepness of 210-211, 213, 215, 217, 221-224, 232, 269, 491-493
surface tension and 212-213, 216-217, 232
tides as 212, 239
trains of 218-220, 232-233
trochoidal shape of 210, 213
troughs of 31, 210-213, 217, 219, 224, 226-228, 232, 246, 249-250, 269, 271-272
wavelengths of 210-212, 230-233, 239, 248-249, 251-252, 254
winds and 212-213, 215, 227-229, 245, 332-334
weather maps 7, 230, 492
weather, weather systems 39, 58, 145, 149, 151-153, 155, 164-166, 168, 170-173, 176-177, 192-193, 227, 230, 284, 475, 477, 480
and Coriolis effect 1-2, 58, 145, 149, 151-152, 161, 164, 166, 168-173, 176-177, 216, 227, 232, 276, 283-284, 301, 467, 475, 477
coastal modification by 267
weathering 120, 139, 141-142, 296
Weddell Sea 198-199, 206
weed cardinalfish (*Foa brachygramma*) 396
Wegener, Alfred 22
well-mixed estuaries 343, 345, 347-348, 351
West Papua, Indonesia 229
westerlies 32, 152, 187, 189, 205, 207
western boundary currents 173, 186-188, 190, 192-193, 198, 205-206, 327, 404
wetlands 2, 30, 35, 132, 134, 267, 280-283, 342, 348-349, 351, 366, 429-432, 443-444, 446, 450-451
whale shark (*Rhincodon typus*) 313
whales 54-55, 116, 299, 313, 315-317, 352, 391, 398, 418, 443, 497
baleen 299, 309-310, 315, 317, 391, 418, 497

- California gray (*Eschrichtius robustus*) 317, 391
 humpback (*Megaptera novaengliae*) 315, 391
 killer (*Orcinus orca*) 299, 315, 317, 411
 whip corals 370, 396
 whip goby (*Bryaninops yongei*) 392
 wide-area echo sounders 43
 willy willys 171
 windrows 194-195
 winds
 coastal modification by 267
 fetch of 32, 168, 214, 221, 232, 333
 geostrophic 1-2, 58, 145, 149, 151-152, 161, 164, 166,
 168-173, 176-177, 216, 227, 232, 276, 283-284, 301, 467,
 475, 477, 491-492
 in wave creation 212-213, 215, 227-229, 245, 332-334
 trade 152-154, 156, 159, 161-162, 166, 170, 174-177, 185-190,
 205, 214, 329
 transport of lithogenous particles by 123
 westerly 32, 152-153, 159, 163, 166-167, 171, 175, 185-189,
 201, 205, 207, 214, 301
 windward 175-176, 213, 408
 World Glory 215
 worms
 annelid 367
 Christmas tree (*Spirobranchus giganteus*) 364, 368, 376
 fan 364, 368, 376
 innkeeper (*Urechis caupo*), lugworm (*Arenicola brasiliensis*),
 plume 366-367
 marine 392
 scale 396, 422
 tube 359-360, 421-423, 425
 wrasses 367, 372, 378-379, 381-382
 cheeklined (*Oxycheilinus digramma*) 379
 cleaner (*Labroides phthirophagus*) 372
 moon (*Thalassoma lunare*) 382
 redbreasted Maori (*Cheilinus fasciatus*) 381
 xanthophylls 494-495
Xenia sp. (soft coral) 363
Xenocarcinus sp. (spider crab) 370
Xenocarcinus tuberculatus (spider crab) 370, 396
 Yangtze (Chang) River 121
 year class strength 335
 Yellow (Huang) River 122
 Yellow Sea 122
 yellow shrimp goby (*Cryptocentrus cinctus*) 397
 Yellowstone Park 81
 yellowstreak fusilier (*Pterocaesio lativittata*) 379
 Younger Dryas period 201
 Yucatan Peninsula, Mexico 170
Zalophus californianus (California sea lion) 316
 zebra lionfish (*Dendrochirus zebra*) 382
 zinc 31, 60, 100-101, 128, 139, 293-294, 296, 422, 428, 501-502
 zooanthids 363
 zooplankton 299, 320
 zooxanthellae 279-280, 282, 326, 333-334, 350, 396-397, 404-405,
 408, 423-424, 446