Index

Names are entered in the index only when not attached to a citation; for cited authors consult the reference list.

Abbott of St. Albans, 318
Abyssal mixing. *See* Mixing
Advective instability. *See* Internal waves
Agassiz, Alexander, 209
Agulhas Current, 82
Air Mass Transformation Experiment (AMTEX), 503
Air–sea interaction, 3, 449–450, 482–503
 boundary layers, 497–503
 boundary layer winds, 500–503
 buoyancy fluxes, 484–485, 498–500
 convective plumes, 498–500
 drag coefficients, 485, 487–490
 flux gradients, 485–486
 gas-exchange, 440
 humidity, 486
 Langmuir circulation, 495
 near-surface profiles, 483–486
 roughness length, 486–487
 surface waves, 491–495
 surface wave spectrum, 491–493
 transfer coefficients, 485–490
Airy solutions. *See* Equatorially trapped waves; Internal waves
Aleutian Trench, 36
American Miscellaneous Society, Albatross Award, xviii
Anelastic equation, 546
Annual variability, 355–357
 on shelf, 223–226, 230, 232
Antarctic Bottom Water, 11, 15–22, 54, 401, 453–456
Antarctic Circumpolar Current. *See* Circumpolar (Antarctic) Current
Antarctic Ocean. *See* Southern Ocean
Arabian Sea, 10, 21
Argentine Basin, 17
Argon (Ar), 447
Aries (vessel), xvi, xxv
Arons, Arnold B., xx
Array design, 431–433
Arthur, Robert S., xxvii
Atlantic Ocean. *See also* General Circulation; Gulf Stream; North Atlantic Ocean; South Atlantic Ocean transports
 boundary currents, 26–29
 early observations of, 7–10
 water mass properties of, 42–69, 71–72, 74–111
Atlantic Tradewind Experiment (ATEX), 503
Atlantis (vessel), xvi, 211, 398
Atmospheric forcing. *See* Meteorological forcing
Atmospheric general circulation, 396, 503–504

Baffin (vessel), 137
Baird (vessel), 398
Baltic Sea, 202
Barbados Oceanographic and Meteorological Experiment (BOMEX), 503
Barber, Norman F., 482
Barium (Ba), 444–445
Baroclinic instability, 141, 169–182, 372–373, 506, 508, 529–532, 545–546
 finite amplitude, 173–177
 linear theory, 169–173

Baroclinic waves. *See* Internal waves; Long waves; Rossby waves
Barotropic instability, 529–532
Batchelor, George K., 482
Battery properties, 401
Bénard convection, 384
Bermuda, xx, 261, 270, 287, 320–321, 348, 359, 364
Bernoulli equation, 117
Bernoulli, Jean, xiv–xv
Beryllium, 447–448
Beta-effect, xv–xvi
Beta-plane, 143–147, 301–302, 344
Beta-spiral, xxi, xxiii, 91, 397
Bigelow, Henry Bryant, xxiv, 209–212
Biology, 3, 376–383. *See also* Property distributions
 ecosystem dynamics, 379–381
 fisheries, 376
 of rings, 379
 spatial variability of, 376–378
 temporal variability of, 377–383
 year class strength, 377
Bjerknes, Carl A., 463–464
Bjerknes, Vilhelm F. K., xxiv
Blake–Bahama Outer Ridge, 28, 121
Blanchard, Duncan C., xx
Bottom trapped waves, 166, 168–169, 311, 315
Bottom water formation, 15–25, 450, 453–456
 near Antarctica, 15–22
 in North Atlantic, 22–25
Boundary layer. *See* Air–sea interaction; General circulation; Gulf Stream
Boundary mixing. *See* Mixing
Boussinesq approximation, 142, 385, 547
Boussinesq equations (convection), 385–386
Box models, 448–450
Bradley, Albert, 413
Bransfield Strait, 15–16
Brown, Neil, 415–419
Brown, Sanborn, 40
Buchanan, John Young, 11
Budyko, Mikhail Ivanovich, 482
Bullard, (Sir) Edward C., xxv
Buoyancy layers, 260
Burger-scale motion, 513, 516–517

Cabbeling, 257
California Current, 342
California, Gulf of, 324–326
Carbon dioxide (CO_2), 434, 439, 447, 456
Carbon-14 (^{14}C), 246, 434–440, 445, 450–460
 normalization, 439
Carbon, total dissolved, 434–440
Caribbean Sea, 84, 475
 model of, 475
Carnegie (vessel), 10, 78–79, 85
 errors in data, 78–79
Carrier, George F., xv, xix
Cayman Basin, 413
Central Indian Basin and Ridge, 10, 32, 36
Cesium (Cs), 446
Challenger expedition, xxvii, 9, 11, 348–349, 429
Charney, Jule G., xv, xx–xxi, xxvii, 482
Chemical tracers, 434–460
 models of distribution, 14–15, 448–450
Chesapeake Bay, 206
Chesapeake Bay Institute, 233
Chlorinity, 418
Circulation. *See* General circulation
Circumpolar (Antarctic) Current, 12, 77, 84, 355, 432–433, 523
Circumpolar deep water, 15
Climate/Long Range Investigation Mapping and Predictions (CLIMAP), 348, 350–351
Clipperton Fracture Zone, 36
Closure schemes, 178, 543
Cnoidal waves, 514, 545
Conductivity. *See* Property distributions
Continental shelves. *See* Shelves, continental
Convection, 384–393, 482. *See also* Mixing processes
 amplitude of, 384–395
 Bénard, 384
 Boussinesq description, 385–386
 deep, 21, 384
 finite amplitude, 386
 heat flux in, 384
 marginal instability in, 386, 391
 mean field theory, 387–389
 in Mediterranean Sea (*see* Mediterranean Sea)
 in ocean, 384
 power integrals, 386
 Rayleigh theory, 384, 386–387
 in shear, 389
 subcritical instability in, 386
 turbulent, 384, 387–393
 turbulent upper bounds, 387–388
 turbulent in shear, 389
 in Weddell Sea (*see* Weddell Sea)
Convective instability. *See* Internal waves
Copepods, 381
Corals, 439
Coral Sea, tides of, 320–321
Corelayer ("*Kernschicht*") method, 43, 57, 75, 79
COSMOS (Complementary symmetry metal oxide semiconductor), 400–401
Cox number, 281
Crease, James, xvi, 411, 420, 430
Critical layers. *See* Internal waves; Wave–mean flow interaction
Croll, James, 8
C-shape (in general circulation), 85, 89–91
Curieuse, La (vessel), xxvi

Dahlen, John M., 399
Dana expedition, 10, 74
Deacon, (Sir) George E. R., 411
Deep water, sources of, 6–26, 107, 457–459
 source models, 17, 19, 20–21, 58
Defant, Albert, xvi, xxiv–xxv
Delaware estuary, 205
Denmark Strait, 408. *See also* Norwegian Sea
 overflow, 23–24, 72, 83
 water (DSW), 83, 453
Deuterium, 448
Deutschland (vessel)
 in ice, 17
 stations, 9
Diagnostic calculations, 85–90, 142
Diffusion. *See* Fickian diffusion; Mixing
Discovery (vessel), xvi, 10
Dissipation (turbulent), 282–284
Double-diffusive convection, instability. *See* Mixing; Salt fingers
Drag coefficients, 485, 487–490
Drag reduction, 391

Drake Passage, 363, 371–372, 425, 430. *See also* Southern Ocean
Draper, Charles S., Laboratory, 399, 406
Dye dispersion, 377–378
Dynamic height (steric height/depth), 73–74, 76, 85, 87–88, 104–105, 107–108, 138
Dynamical method. *See* Geostrophy

Eady, Eric T., 482
Eastern boundary currents, 151–152, 154
East Pacific Rise, 35
Eddies, 313–314, 342–343, 358–373, 430–432, 507–508. *See also* Baroclinic instability; Mixing
 in Arctic Sea, 371
 diffusion, xix
 eddy–mean flow interaction, 507
 Gulf Stream, 117–119, 373–374, 507
 heat flux by, 372–373, 384
 modal structure, 371–372
 Reynolds stresses, 372, 507–508
 on shelf, 212
 Soviet study of, 359
 spin-down, 527–529
 topographic interaction, 370–371, 373
 western boundary currents, 373
Eddy coefficients, 342, 345
Eddy-containing band, 359, 370, 373
Edge waves, 307, 309–317. *See also* Shelf waves
Ekman dynamics, 147–149, 506. *See also* Spin-up/down
 flux, 20, 148
 laboratory models, 463–464
 layer, 140–141, 147–148, 463–471, 525–526
 pumping, xxi, 506, 520, 527
 turbulent, 149
Ekman, V. Walfrid, xxiv
Ellis, Henry, 7
El Niño, 192–193, 379, 397–398
Eltanin (vessel), 43
Enstrophy, 175, 346, 529, 543–544. *See also* Potential vorticity
Entrainment. *See* Mixing
Equatorial circulation, 83, 184–196. *See also* General circulation; North Equatorial Countercurrent; North Equatorial Current; South Equatorial Countercurrent; Undercurrents, equatorial
 cross-equatorial flow, 109
 deep jets, 194
 theory of, 185, 188–195
 upwelling, 192, 456
 variability, 184
Equatorially trapped waves, 186, 191–193, 295, 304–308, 513, 527
 Airy solution, 306–307
 Kelvin wave, 191–192, 305, 527
 nonlinear, 516
Erika Dan (vessel), 43
Estuaries, 198–207. *See also* Chesapeake Bay; Maine, Gulf of; Puget Sound
 circulation, 199–204
 classification of, 202
 current measurements in, 200–201
 flushing of, 202
 mixing in, 203–240
 salt balance, 205
 salt-wedge, 203, 205
 sea-level fluctuations in, 206
 theories of, 203–207
 tidal flow in, 200
 tidal mixing in, 206
 turbulence in, 205–206
Ewing, W. Maurice, xiv
Experiment design, 429–433

Faller, Alan J., xvii, xxi
Faraday, Michael, 396
Fickian diffusion, 239
Fine structure, 257–258, 268, 279–284, 418
 intrusive, 279–282
Finland, Gulf of, 201
Fish population, 376–379
Flamsteed, John, 318
Floating instrument platform (FLIP), 265, 398, 428
Floats. *See* Instruments
Florida Straits. *See* Gulf Stream
Fluorometric techniques, 376
Fofonoff, Nick P., xvi, xx
Fofonoff's rule, 285
Food web, 376–383
Form-drag instability, 534–539
 on topography, 538–539
Frantz, David, xvi
Freon, 447
Friction, lateral, 151–152. *See also* Ekman dynamics; Tides; Wind-driven circulation
Friedman–Keller equation, 484
Fronts and biological productivity, 377–378
Fuglister, Frederick C., xxi

GARP. *See* Global Atmospheric Research Program
Garrett–Munk spectrum. *See* Internal waves
Gas exchange, 440
GATE. *See* Global Atmospheric Research Program
GEK. *See* Instruments
General circulation, 6–41, 70–111, 140–183. *See also* Gulf Stream; Name of ocean
 Antarctic sources, 8–11, 15–22
 Arabian Sea, 9–10
 and chemical tracers, 434–460
 C-shape in, 85, 89–91
 deep, 6–41
 dynamics of, 140–183
 eastern boundary currents, 151–152, 154
 equations for, 142–147
 equatorial, 83, 184–196
 history of, 7–11, 70–79
 Indian Ocean, 29–34
 isopycnal analysis of, 81–85
 Mediterranean outflow (*see* Mediterranean Sea)
 meridional circulation, 75
 mid-depth, 70–111
 models (*see* Laboratory models)
 numerical models, 85–90, 140–141, 155–157, 175–182, 507–508
  diagnostic, 89–90, 111
 Persian Gulf source, 10, 25–26
 Red Sea source, 10, 25
 sinking regions, 15–25
 thermocline circulation, 141, 158–163
 topographic effects on, 151–152
 tropical, 185–186, 188–190
 undercurrents, western boundary, 11, 26–38, 79, 121–122
  discovery of, xvi, xxi, 11, 13
 upwelling in, 162–163, 358, 456
 variability, 71–72

western boundary currents, 12, 14, 26–38, 79
models of, 37–38, 140–141, 149–151, 153–157, 531–532
separation of, 141, 157–158
wind-driven circulation, 71, 79, 140–142, 149–157
General circulation of atmosphere, 396, 505–506
Geochemical Ocean Sections Studies (GEOSECS), xvii, xxii, 435–460
Geochemical tracers, 434–460
modeling, 448–449
Geomagnetism, 384
Geophysical Fluid Dynamics Seminar, xxi–xxii
Georges Bank, 209
GEOS-3, 324
GEOSECS. *See* Geochemical Ocean Sections Studies
Geostrophic turbulence, 509, 543–544, 546
Geostrophy, 72–73, 82, 108–109, 140, 233, 397, 508–509
compared to numerical models, 89–91
Gibbs Fracture Zone, 23
Global Atmospheric Research Program (GARP), Atlantic Tropical Experiment (GATE), 191, 193, 503, 544
Glomar Challenger (vessel), 398
Goody, Richard, xxi
Grampus (vessel), 209
Grand Banks, circulation near, 85, 133, 135, 138
Gravity currents, 260
Guinea, Gulf of, 191
upwelling in, 193
Gulf Stream, xiv–xv, xx–xxi, xxv, 2, 71, 78, 81, 85, 112–139, 506. *See also* General circulation
atmospheric forcing of, 117, 119–121, 125, 131
branching of, 84–85, 138
decay, 135
deep flows, 26–29, 127
"Charleston Bump," 121
eddy generation, 359
eddy–mean flow interaction, 117–119, 127, 129–131, 134
Florida Current, 113–122
heat flux, 137
infrared images of, 113–115, 124, 135–136
instability of, 119–121, 529
laboratory models of, 465–466
meanders, 123–125, 529, 533–534, 545
North Atlantic Current, 113, 133–138
numerical models of, 132–133
at Onslow Bay, 118–119
oxygen distribution, 137
path models, 126–127
potential vorticity distribution, 121–122
pressure gradient in, 118–119
radiation from, 524–525, 531
recirculation, 79, 123, 131, 397, 533–534
rings, 125, 132, 137, 345, 527–529, 534
rings and biological effects, 379
rings, models of, 476
sea-level slope, 114, 116
separation from coast, 125–126, 139, 141, 157–158
system names, 113
shingles, 117
theories of, 119–120, 127, 129, 132–134
trajectory models, 126–127
transport of, 121, 123, 131, 355
variability of, 116–117, 127–130, 357, 429–430
undercurrent, 121–122
and waves, 119–121, 531–532
Gulf stream '60, 126

Hadley cell, 506
Hales, Stephen, 7
Hamon, Bruce V., 415
Hansen, Armauer (vessel), 398
Harvard University, xviii, xxi–xxii
Heat flux, 482
in ocean, 58, 137–138
Helium-3 (^{3}H), 434, 444–445
Helland-Hansen, Bjørn, xxiv–xxv, 398
Hill, Winfield, 401
Horizon (vessel), 398
Howard, Louis N., xxi, xxiii
Hydrographic data coverage, 44–46
Hypothesis testing, xiii, 429–430

Ice
bottom water formation, role in, 17, 19–21
mixing, 252
Iceland–Scotland overflow, 22–24
Indian Ocean, 109. *See also* General circulation
boundary currents, 29–34
early observations of, 10
water mass properties, 42–49, 93–111
Indian Ocean Bubble, The, xxv
Indian Ocean Experiment (INDEX), xxvi
INDOPAC expedition, 57
Inertial subrange, 239
Inertial waves. *See* Internal waves
Infrared measurements, 114–115, 120–121, 124, 135–136, 186, 193, 231, 426–427
Instability. *See* Baroclinic instability; Barotropic instability; Form-drag instability; Kelvin–Helmholtz instability
Institute for Advanced Study, xx–xxi
Institute of Oceanographic Sciences (IOS), 411
Instruments, 342–343, 374, 396–428
acoustic doppler, 266–267
acoustic releases, 407–409
acoustic tomography, 374, 428
bathythermograph
BT, 212, 264, 267, 414
XBT, 414
XSV, 414–415
batteries, 401–402
conductivity measurements, 42, 415–419
CTD, 267, 402, 414, 416, 418–419, 428
current meters, 265, 398–399, 403–407
Aanderaa, 405–406
errors in, 404–405
vector averaging, 400, 404
vector measuring, 404–405
vertical, 403
Cyclesonde, 424
drift bottles, 212–213
drifters, 426
electronics, role of, 399–401
electromagnetic measurements, 422, 425–426
geomagnetic electrokinetograph (GEK), 117, 422
history of development, 398–400
inverted echo sounders, 428
laser-Raman backscatter, 428
mooring systems, xvi–xvii, 407–410
mooring technology, 402–404
neutrally buoyant floats, 2, 359, 397, 410–413, 430
SOFAR floats, xvii, 27, 412–413
optical imagers, 419–420
pressure gauges, 323, 399–400, 424–425

profilers, 265–266
air-dropped, 421–422
salinity, 414–420
sound, 414
temperatures, 267, 414
velocity, 267, 420–424
salinometers, 42, 44, 416
satellites, 265, 323–324, 426–427
altimeters, 323–324, 374, 427–428
infrared, 426–427 (*see also* Infrared measurements)
Savonius rotor, 403–406
SONAR, 428
sound, 264–265, 403, 414, 428
STD, 267, 402, 414–418
submarines, 265
surface drifters, 426
synthetic aperture radar (SAR), 266
tape recorders, 401–402
temperature-gradient recorder, 400
temperature–pressure (TP) recorders, 399, 406–407
thermometers, 7–8, 10
towed, 265
use on continental shelf, 209, 212, 213
White Horse, 421
Interannual band, 373
Interannual variability, 348–355
Internal tides. *See* Tides
Internal Wave Experiment (IWEX), 265, 285
Internal waves, 264–291
Airy function representation, 271
breaking of, 276
critical layers, 248, 273–275
discovery of, 264
dispersion relations, 269–271
dissipation in, 288–290
energy balance, 288–289
and fine structure, 268
Garrett–Munk (GM) spectrum, 285
generation of, 288–289
in continuously stratified ocean, 269–271
inertial waves, 272–273, 332
instability, 276–279, 287–290
laboratory models, 270
in layered ocean, 268–269
measurement, 264–265
and microstructure, 267
in mixing budget, 246
mixing from, 247–250, 261, 267, 289–290
on equator, 272–273, 286
parametric instability, 248
reflection of, 270
resonant interactions of, 272–273, 275–277
and Richardson number, 268
saturation, 287–290
in shear, 273–275
spectra, 264–265, 285–286, 290, 414
theory of, 264
and topography, 270–271, 286, 316–317
traumata, 279
turning-point solutions, 271–273
universality, 285–286
in waveguide, 271–272
waveguide solutions, 271–273
International Decade of Ocean Exploration (IDOE), xvii
International Ice Patrol, 233
International Indian Ocean Expedition (IIOE), xxv
International Southern Ocean Studies (ISOS), 14, 430, 432–433
Intertropical Convergence Zone (ITCZ), 187–188, 192
Inverse methods, 91–92, 397, 428
Inverted barometer, 351
Irminger Sea, 72
Iselin, Columbus O'Donnell, xxiv–xxv, 212, 430
Island trapped waves, 358
Isopycnal analysis, 81–85
ISOS. *See* International Southern Ocean Studies
Isotropic band, 359

Jacobs, Woodrow C., 482
James River, 203, 204
Japan, Sea of, 53
Joint Air–Sea Interaction Experiment (JASIN), 244, 503
Joint North Sea Wave Project (JONSWAP), 491–495
Jordan, William Leighton (Award), xxvi–xxvii

Kattegat, 199
Kelvin–Helmholtz instability, 249, 277–279
billows, 249
Kelvin, Lord (Sir William Thomson), 318
Kelvin waves, 222, 298–299, 316, 358
Kivu, Lake, 252–253, 256
Koehler, Richard, 401, 404, 421
Kolmogorov inertial subrange, 239
Korteweg–deVries equation, 345, 513–517
Krypton (Kr), 446–447
Kuo, Hsiao-Lan, xxi
Kuroshio, xxiii, 71, 540–543

Laboratory models, 3, 140, 152–153, 201, 203, 248–249, 270, 462–479
of circulation, 465–473
history of, 463–464
Langmuir circulation, 477–478
of Rossby waves, 474–475
of rings, 476
of sills and weirs, 473
philosophy of, 462–463, 478–479
sliced cylinder, 469–473
source–sink, 466–468, 472–473
spin-up, 476–477
Labrador Current, 208
Labrador Sea, 11, 25, 72, 75, 79, 84
Labrador Sea Water, 453–454
Lagrangian means, 181–182, 345, 473–475
Lakes
boundary layers in, 149
convection in, 252–253, 256
mixing in, 459–460
Langmuir circulation, 477–478, 495
Laplace, Pierre-Simon, xv
Laplace tidal equations, 291, 295–297. *See also* Long waves; Rossby waves; Tides
free oscillations of ocean, 317
numerical solutions, 328–329
Law of the wall, 238, 502
Lead(^{210}Pb), 445
Lee waves, 332, 334, 522–524
Lettau, Heinz Helmut, 466
Lin, Chia-Chiao, xxi
Loch Ness, 244, 291
Longuet-Higgins, Michael S., xix
Long waves, 292–341. *See also* Rossby waves; Shelf waves; Tides

on plane, 297–299
in stratified fluid, 299–300
Lorenz, Edward N., xxi
Love numbers. *See* Tides
Low-frequency variability, 6–7, 72, 342–374, 509–517. *See also* Annual variability; Eddies; Gulf Stream; Shelf waves; Rossby waves
history of study, 72, 343–344
interannual, 348–355
mesoscale, 357–373
meteorological forcing of, 346–348, 373
models of, 347
spectrum of, 343, 348, 363–372
and turbulence, 345–346

McCullough, James R., 401
Madagascar Basin, 29
Maine, Gulf of, 201, 209
Malkus, Joanne S., xxi
Malkus, Willem V. R., xxi, xxiii, xxvii, 411
Marginal Seas, 25–26. *See also* Name of sea
Margules, Max, xv
Marine Ecosystem Analysis Program (MESA), 213
Massachusetts Institute of Technology (MIT), xviii, xxi–xxii, xxiv, xxvi, 399, 408, 466
Mediterranean Sea, 71, 413
convection in, 22, 25, 199
outflow, 10–11, 14, 252, 371
Méditerranée-Occidentale (MEDOC), xxii–xxiii
Mersey River, 204–205
Mesecar, Roderick S., 402
Mesoscale eddy. *See* Eddies
Meteor expedition, 10, 74–75, 264, 348
Meteorological forcing, 346–348
in Gulf Stream, 119–121
on shelf, 214–217
in tropics, 185–186
Meteorology. *See* Air–sea interaction; Atmospheric general circulation
Michael Sars expedition, 264
Microstructure, 257–258, 267, 279–284, 418–420
Mid-Atlantic Ridge fracture zones, 29
Middle Atlantic Bight, 148–233. *See also* Estuaries; Maine, Gulf of
Mid-Ocean Dynamics Experiments (MODE-0, MODE-1), xvii–xviii, xxii–xxiii, 131, 335, 359, 363, 370, 397, 407–408, 412, 421–423, 428, 430–432, 544–545
MIDPAC expedition, 400
Mixed layers, models of, 240–243, 385
Mixing, 3, 84, 203, 236–262, 267, 279, 337, 339, 449. *See also* Fickian diffusion; Internal waves; Kelvin–Helmholtz instability; Kolmogorov inertial subrange; Law of the wall; Mixed layers; Monin–Obukhov length; Ozmidov scale; Richardson number; Thermocline
in Antarctic, 15–22, 257
near bottom, 258–262
in circulation, 84
coefficients, 236, 237, 256
by convection, 237, 243–245
double diffusive instability, 250–257
in estuaries, 240
with ice, 252
in ocean interior, 245–258
in Red Sea, 252
Reynolds analogy, 238
in shear flows, 238
and stirring, 267
vertical, 459–460
in Weddell Sea (*see* Weddell Sea)
Mixing processes, 183, 237, 434, 449. *See also* Internal waves; Richardson number
boundary, 259–602
cabelling, 257
convective, 250–257
entrainment, 240–241
external, 237, 241–243
with ice, 252
interfacial shears, 248–250
internal, 237–260
intrusive, 250, 253
isopycnal, 81–82
mechanical, 246–250
"neighbor separation," 239
rates (vertical), 459–460
surface driven, 241–243
turbulent, 236, 239–240
from wave instability, 247–250
MODE. *See* Mid-Ocean Dynamics Experiments
Models. *See* Laboratory models; General circulation
Mode water, 59, 83
Molecular processes, 250–257, 260–261
Monin–Obukhov length, 239, 482, 484–485
Monsoon, 191, 429, 524
Montgomery, Raymond B., xiv, xix
Morgan, George W., xv, xx
Mosby, Håkon, xxiv–xxv, 415
Multiple equilibria, 539–543
Munk layer. *See* General circulation
Munk, Walter H., xv, xix, 399, 482

Nansen, Fridtjof, xxiv
National Institute of Oceanography (NIO), 411
National Oceanic and Atmospheric Administration (NOAA), 213–214
Newton, Isaac, xiv–xv
Ninetyeast Ridge, 10, 32–33, 36
NIO. *See* National Institute of Oceanography
Nitrogen (N), 448, 453–454
NOAA. *See* National Oceanic and Atmospheric Administration
North Atlantic Current. *See* Gulf Stream
North Atlantic Ocean
bottom-water formation in, 22–25
deep water, 7, 11, 22, 25, 74–75, 77, 453–456
North Equatorial Countercurrent (NECC), 185, 188–189
North Equatorial Current (NEC), 185
North Pacific Experiment (NORPAX), 184
Norwegian Sea, 58, 84, 99, 111, 343
overflow, 22–24, 58
Nuclear testing, 434, 439
Numerical models. *See* General circulation
Nusselt number, 254, 388–393
Nutrients. *See* Property distributions

Objective analysis, 431–433
Observational strategies, 397–398, 430–433
Obukhov, Aleksander Mikhailovich, 482
Ocean–atmosphere analogues, 504–548
Oceanography
evolution of, xiii, 3
history of, 2–3
Ocean volumes, 49
Operation Cabot, 212
Overflow. *See* Deep water, sources of; Name of source

Oxygen distribution, models of, 14, 33, 81. *See also* Property distributions
Oxygen (^{18}O), 448
Ozmidov scale, 239, 250

Pacific Ocean
boundary currents, 34–37
early observations of, 10–11
water-mass properties, 42–49, 71–72, 82–111
Palmén, Eric H., xxiv
Panama Basin, 35–36
Panulirus (vessel), xx
Parametric instability, 248
Particulate matter, 434
Pelagic organisms, 378–379
Persian Gulf, 10, 26
Phillips, Norman A., xxi
Photosynthesis, 382
Planetary waves. *See* Rossby waves
Plankton, 379–383
Poincaré waves, 298
Polonium (^{210}Po), 445
Polygon, 543
Polymer drag reduction, 391
POLYMODE, xvii–xviii, xxiii, 131, 359, 363, 544
Potential vorticity
and baroclinic instability, 169–173
conservation of, 142, 397, 509–511
Prandtl number, 285
Pressure fluctuations (oceanic), 303–305, 348, 475
Priestley, Charles H. B., 482
Property distributions, 6, 14, 43, 93–103, 448. *See also* (under specific tracers) Carbon-14; Tritium; etc.
chlorophyl, 377, 380–381
density, 74–75, 81–90, 93–95
nitrate, 377
nutrients, 80
oxygen, 14, 33–34, 75, 77, 81, 98–99, 106
phosphate, 75, 81, 100–101, 107
salinity, 93, 96–97, 106, 210
deep, 10, 18
silica, silicate, 18, 25, 33–35, 59, 102–103, 107
temperature, 18, 73
deep, 6
Pseudopotential vorticity, 519
Puget Sound, 206

Quasi-biennial oscillation, 532
Quasi-geostrophic motion, 141–147, 311, 508–509, 517–520, 544, 546–548. *See also* Geostrophy
Quasi-geostrophic turbulence. *See* Geostrophic turbulence

Radium (Ra), 444–446
Radon (Rn), 446, 459–460
Rayleigh, Baron (J. W. Strutt), 384
Rayleigh number, 239, 385–393
critical values of, 251
Rayleigh's theorem, 530–532
Recirculations. *See* Gulf Stream
Red Sea, 10, 25–26, 199
Research vessels, 398
Residence time. *See* Ventilation times
Resonant interactions, in surface waves, 494
Reynolds stresses, 486–487, 507–509, 533
Richardson, Lewis F., xix, xxv
Richardson number
equilibrium, 246–247
flux, 238, (255), 495
gradient, 238–239, 244, 246, 249, 267, 268, 287, 485
Richardson, William S., xvi
Rings. *See* Gulf Stream
Robinson, Allan R., xviii, xxi
Rochford, David J., 415
Roll, Hans U., 482
Ross Sea, 15, 21
Rossby, Carl-Gustaf A., xxiv, xxvi
Rossby radius of deformation, 183, 517
Rossby waves, xv, 141, 164–169, 300–303, 344–346, 472, 511–513, 520–526, 545–548
baroclinic, 166–169
instability of, 531, 534–538
in layers, 164–165
mean flow, interaction with, 532–534
models of, 472, 474–475
nonlinear, 513–517
topographic effects on, 165–169, 310, 520–524
Rumford, Count (Thompson, Benjamin), 8, 38–40

Salinity. *See* Property distributions; Estuaries
Salinity scale, 418
Salinometers. *See* Instruments
Salt fingers, xx, 250, 255, 419
collective instability, 252
Salt fountain, xvii, xx, 250, 419
Samoan passage and basin, 35
Satellite altimetry. *See* Instruments
Satellite infrared measurements. *See* Infrared measurements
Savonius rotor. *See* Instruments
Schmitz, William J., Jr., 421
Scripps Institution of Oceanography, xx, 398–399, 408
Sea-Data Corp., 401–402
Sea level, 114, 116. *See also* Gulf Stream; Tides
annual changes, 355–357
geodetic leveling of, 211–212
variations, 191, 351–353
SEASAT, 266, 324, 374
Seasonal variability, 355–357
on equator, 186–189
Semigeostrophic motion, 508, 517
Shear flow, convection in. *See* Convection
Shelf waves, 222–223, 312, 358. *See also* Edge waves; Shelves, continental
Shelves, continental, 207–233. *See also* Instruments; Ross Sea; Shelf waves; Weddell Sea, Bigelow, Henry Bryant; Tides
annual variability, 223–226, 230, 232
atmospheric forcing of, 214–230
circulation, early ideas on, 208–213
circulation of, 217–226
dumping on, 212
flushing time, 212, 230
Georges Bank, 209
Middle Atlantic Bight as typical shelf, 198
Middle Atlantic Bight physiography, 208
models of, 222, 227–230
pressure gradients, 227–229
sea level in, 211, 220, 222, 227–229
sediment movement on, 218
storm driven currents, 214
transports, 214
velocity modes, 219–220
water masses of, 208, 233

Silica-32 (^{32}Si), 447
Sippican Corporation, 414
Slope water, 137
Snellius Expedition, 264
Snodgrass, Frank E., 399
Society of Subprofessional Oceanographers (SOSO), xxvii
SOFAR float. *See* Instruments
SOFAR (sound fixing and ranging) channel, 412
Solitary waves, 512–514, 543; *See also* Korteweg–de Vries equation
Somali Current, 192
Source–sink experiments, 466–468, 472–473
South Atlantic Ocean transports, 28
South Equatorial Countercurrent (SECC), 185
South Equatorial Current (SEC), 185
Southern Ocean, 46, 72, 110, 117. *See also* General circulation; International Southern Ocean Studies (ISOS)
 bottom-water formation in, 15–22
 water-mass property, 42–69, 83–84
Southwell, (Sir) Richard, v, xix, xxv
Spin-up/down, 476–477. *See also* Ekman dynamics; Laboratory models
 and eddy field, 525–529
Spitzer, Lyman, xix
Spreading (*Ausbreitung*) of water masses, 11
SPURV (Self-Propelled Under Water Research Vehicle), 413–414
Steric height. *See* Dynamic height
Stern, Melvin E., xx–xxi
Stewartson layer, 469, 471
Stokes velocity, 206, 345, 472, 534
Stommel–Arons circulation model, xvii, xxi, 12–14, 162–163, 397
Stommel, Henry M., v–xxxiii, 2–3, 7, 411, 482
 publications, xxviii–xxxiii
Stommel layer. *See* General circulation
"Strange attractors," 387
Strontium (Sr), 446, 456
Stuart, John T., xxi
Surface drift, on shelf, 209–213
Surface heating, 243
Surface waves, 242, 482–483
Sverdrup, Harald U., xix, xxiv–xxv, 482
Sverdrup relationship (balance), xix, 79, 81, 140, 149–152, 182, 188, 344–345, 509, 517, 527
Sverdrup waves, 298
Swallow floats. *See* Instruments
Swallow, John C., xvi, 411–412, 420, 430
Synoptic scale, 343, 506, 548; *See also* Eddies
Synthetic aperture radar. *See* Instruments

T–S relation, 42, 44–69
Tasman basin, 34–35
Taylor–Goldstein equation, 273
Temperature anomalies
 Atlantic, 354
 Pacific, 353–356
Temperature, history of measurement, 7
Temperatures. *See* Property distributions
Temperature–salinity relation. *See T–S* relation
Thermocline
 seasonal models (*see* Mixed layers)
 structure, 245
 theory of, xxi, 38–40, 158–163, 243–245
Thermohaline convection. *See* Convection; Mixing; Salt fingers
Thymol-blue technique, 472
Tidal motions of the second class. *See* Rossby waves
Tide gauges, 424–425. *See also* Instruments, pressure gauges
Tides, 292–341, 399
 admittance, 320–321
 at Bermuda, 320–321
 charts, 318–320
 in Coral Sea, 320–321
 dissipation, 320–324, 337–339
 energy of, 322
 generating forces (equilibrium tide), 293–295
 history of, 292–293, 318–320
 internal, 286, 293, 329–340
  generation of, 331–334
  as lee waves, 332
  mixing in, 333–334, 337, 339
  observations of, 334–337
  on slopes and shelves, 334–337
 island effects, 327
 long period, 339–341
 Love numbers, 296
 models, global, 328–330
 models, regional, 324–328
 and oceanography, 339–341
 pole tide, 339
 predictions, 318
 Q, 322–323
 radiational forcing, 294–295
 and rotation of earth, 322–323
 self-gravitation of, 296–297
 on shelves, 326–327
 solid-earth deformation, 296–297, 323, 339
Tonga–Kermadec Trench and Ridge, 34–35
Topographic waves. *See* Edge waves; Rossby waves; Shelf waves
"Traditional" approximation, 295, 297
Tritium (^{3}H), 440–444, 456–460
Tucker, Malcolm J., 411, 420
Turbulence, 141–142, 174–177, 265, 405. *See also* Estuaries
 in atmospheric boundary layer, 483–490
 geostrophic, 509, 543–544
 laboratory models of, 473–474
 mean flow generation, 473–474
 on topography, 177–182
Turbulence in stratified flow, 238–247
Turbulent convection. *See* Convection
Turbulent shear flow, 238
Turner, J. Stewart, xx–xxi
Tuscarora (vessel), 10

Undercurrents, equatorial. *See also* Equatorial circulation
 in Atlantic Ocean, 185
 discovery of, 11, 184, 185
 in Indian Ocean, 185, 429
 in Pacific Ocean, 184–185, 429
 theory of, 189–191
 variability of, 186
Undercurrents, western boundary. *See* General circulation; Gulf Stream
Upwelling, 358
 equatorial, 456
 in Gulf of Guinea, 192
Ursell, Fritz J., 482

Valdivia (vessel), 10
"Van Allen" effect, 399

Variability. *See* Interannual variability; Internal waves; Low-frequency variability
Vema (vessel), 398
Ventilation times, 449–459
 of deep sea, 449–456
 of thermocline, 456–457
Venus, circulation of, 506
Veronis, George, xxvi–xxvii
Vessels, oceanographic, 398
Vinci, Leonardo da, 432
Volkmann, Gordon, 412
Volumetric census, 42–69
von Arx, William S., xxi, 465–466
Voorhis, Arthur D., 421
Vorticity balance, 12

Walker circulation, 353
Walvis Ridge, 28–29, 40
Water masses, 42–69
 formation of, 57–59
 table of volumes, 60–69
Wave–mean flow interaction, 532–534, 545–546, 548
Waves. *See* Equatorially trapped waves; General circulation; Kelvin waves; Internal waves; Rossby waves; Shelf waves; Surface waves
Webb, Douglas C., 412
Webster, T. Ferris, xvi
Weddell Sea, 12, 15–22
 bottom water, 15, 17–20
 circulation gyre, 17
 mixing in, 260
West Australian Basin, 32, 35
Western boundary currents. *See* General circulation; Gulf Stream
Whewell, William, 318
Wilkes Land, 22
Wind-driven circulation, 71–79, 140–142, 149–157
Wind field. *See* Air–sea interaction; Meteorological forcing
Woodcock–Wyman expedition, 482
Woods Hole Oceanographic Institution, xiv, xviii–xxvii, 233, 398, 403, 407–410
 Buoy Project, xvi, 407–410
Worthington, L. Valentine, xxvi–xxvii
Wunsch, Carl, xviii, 399

Yale University, xiv, xix, xxi–xxii
Yoshida jet, 192