**Index**

| ABC (acceptable biological catch) | 141 |
| adaptation of Wshing communities | 59–63 |
| Ahmed, M. vii | |
| Álesund 40 | |
| Alheit, J. 238, 297 | |
| Alston, J. 221 | |
| alternative occupations of fishers 59, 112, 123–4 | |
| see also supplementary occupations of fishers | |
| anchovy see South African pilchard/anchovy fishery model | |
| aquaculture | |
| as alternative occupation for fishers 59, 123 | |
| as source of demand for fish product 139–41, 262, 265 | |
| Arctic Climate Assessment study 5 | |
| Arminston, P. 221 | |
| Arnason, R. vii, 72, 74, 76, 78 | |
| Asche, F. 273 | |
| Asian fisheries | |
| catch levels 216–17 | |
| climate change 218–20 | |
| climate change impact model approaches 220 | |
| conclusions 231–2 | |
| numerical implementation 221–3 | |
| results 223–31 | |
| structure 220–21 | |
| overview 215 | |
| species 232–3 | |
| stocks 217–18 | |
| Askøy 38 | |
| Astthorsson, O.S. 108 | |
| Atlantic–Pacific correlations 120–22 | |
| Atlanto-Scandian herring see Norwegian spring-spawning herring | |
| Bakun, A. 237, 262, 265 | |
| Barange, M. vii–viii, xv | |
| Barnett, T.P. 237 | |
| Barreteau, O. 268 | |
| Barrowman, N.J. 152 | |
| Baumgartner, T.R. 128, 135, 155, 237, 238, 302 | |
| Beamish, R.J. 297 | |
| Beaugrand, G. 299, 302 | |
| behaviour, migratory | |
| Norwegian spring-spawning herring 67–9, 101–8 | |
| Pacific sardine 126 | |
| Belkin, I.M. 108 | |
| Bellman, R. 21 | |
| Bergen 37, 40 | |
| Bevertón, R.J.H. 272 | |
| big herring fishery 36–7, 39 | |
| bioeconomic models 268 | |
| Bjørkvik, E. 114 | |
| Bjoerndal, T. 17, 76, 98, 238, 239, 273 | |
| Bømlo 60–61 | |
| Botsford, L. 219 | |
| Boyer, D.C. 205, 206, 207, 208, 299 | |
| Briones, R.M. viii, 268 | |
| Butterworth, D.S. 152, 155, 156, 157, 164, 195, 200, 202, 206, 208, 210 | |
| capelin see winter capelin fishery | |
| catch rate per unit effort (cpue) 201 | |
| Chavez, F.P. 128, 218, 219 | |
| Chinese fisheries 263, 292 | |
| Cisneros-Mata, M.A. 263 | |
| Clark, C.W. 6, 12, 236, 268 | |
| Clark, F.N. 126, 129, 147, 149 | |
| climate change impacts abrupt changes 297–8 | |
| Asian fisheries 218–20 | |
| empirical evidence for 237–8 | |
| marine ecosystems 263–5 | |

305
modelling
  competitive fishery 15–18, 29–30
  considerations 5–8
  optimal fishery 9–15, 27–8
  stochastic case 18–25
Namibian pilchard 208
Norwegian spring-spawning herring
  85–8
Pacific Northwest sardine fishery
  146–7
Pacific sardine 128, 129–31
predictions 1–5, 25–7, 296–7
_Clupea harengus L._ see Norwegian spring-spawning herring
Cochrane, K.L. 163
cod 238
Collie, J.S. 152
Conser, R.J. 136
CPS (coastal pelagic species) 126
cpue (catch rate per unit effort) 201
Cram, D.L. 208
Crawford, R.J.M. 209
Cripe, G. viii, 240
Csirke, J. 262
Cushman, R.M. 262
Dalzell, P. 217, 219
de Leiva Moreno, I. 263
De Oliveira, J.A.A. xii, 152, 155, 156,
  157, 163, 164, 170, 193, 195, 200, 202
DeAngelis, D.L. 262
Delgado, C.L. 220, 268
demand for fish product 265
  see also aquaculture, as source of
demand for fish product; Japan,
demand for sardine; supply-
demand models
Devaraj, M. 216
Dey, M. 217, 220, 268
Dickson, R.R. 108, 238
Differbaug, N.S. 265
Duffy, J. 268
Durand, M.-H. 262
East Iceland Current, cooling of 69
  eel see sand eel fishery
EEZs (exclusive economic zones) 66–7
empirical evidence for climate change
  phenomena 237–8
Engeseter, S. 66, 67, 98
EU–Norway fishing agreements 67
exclusive economic zones (EEZs) 66–7
Failler, P. 268
Färe, R. 148
Farrell, M.J. 148
Fasting, K. 48, 114
fat herring fishery 36–7
Fedje 60–63
Finney, B.P. 237
fisheries management 292, 302
fisheries management plan (FMP)
  see PFMC fishery management
  plan
fishery collapses 298–300
fishing vessel categories 196–7
Floro 40
Floros, C. 268
FMP see PFMC fishery management
  plan
Francis, R.C. 219, 237
Fréon, P. viii–ix, 262, 278, 292
Frey, H.W. 129
fuel per trip-hour 200
Gammelsrod, T. 208
Garces, L. ix
Garcia, S.M. 263
Gislason, A. 108
global warming 301, 303
Golubtsov, P. ix, 240, 255, 258
Gordon, H.S. 236
Gréboval, D. 262
Hagen, E. 238, 297
hake see Namibian hake
Hamilton, L.C. x, 109, 122, 123
Hampton, I. 205, 206, 207, 208
Hamre, J. 67
Hannesson, R. x, 6, 16, 67, 300
Hardin, G. 58
Hare, S.R. 237, 299, 302
Hart, J.L. 126
harvest formula see maximum
  sustainable yield
Haugesund 40
Hedgcock, D. 126
Herrick, S.F., Jr x
Herring Era Museum 109
herring game see Norwegian spring-spawning herring, game theory biomass model
herring girls 109
herring stock fluctuation causes, Norwegian fisheries 47–8
herring towns rise and fall 100–101, 122–4
see also Fedje; Neskaupstaður; Rákvág; Seyðisfjörður; Siglufjörður
herring types 36–7
Hilborn, R. 152, 272
Hill, K.T. x–xi, 135
Hollowed, A.B. 237
Holmes, B. 262
Holt, S.J. 272
Hordaland county 37–44, 49, 51–2
horse mackerel 213
Hull, J.C. 20
Hurrell, J.W. 108, 238
Iceland
herring fishery 36–7
see also Neskaupstaður; Seyðisfjörður; Siglufjörður
IMR (Institute of Marine Research) 48, 50
India
climate change model results 223–7
see also Asian fisheries
Indo–Pacific mackerel 216–17
see also Pacific mackerel
Institute of Marine Research (IMR) 48, 50
interdecadal variability 151
see also Pacific Decadal Oscillation
Intergovernmental Panel on Climate Change (IPCC) 1, 301
IPCC (Intergovernmental Panel on Climate Change) 1, 301
Isaacs, J.D. 155
jack mackerel 128, 136
Jacobson, L.D. 129
Janssen, J.F., Jr 126, 149
Japan, demand for sardine 143–4
Johansen, E.K. 39, 40, 41, 42, 45, 48, 49, 52, 53
Johnston, R.J. 302
Jónsson, S. 69, 86
Kagel, J.H. 268
Kaitala, V. 72, 73, 76, 94, 95, 96
Kamien, M.I. 18, 21
Kawasaki, T. 297
Kell, L.T. 152
Kent, G. 215
king mackerel 232
Kirkwood, G.P. 152
Klyashtorin, L. 218
Kristinsson, Ó. 102, 109, 111
land-seining 40, 42, 116
Lear, W.H. 238
Lehodey, P. 298, 299
Leiva Moreno, I. de 263
Levhari, D. 236, 258
Lindebo, E. 262
Lindroos, M. 72, 73, 76, 94, 95, 96
Lluch-Belda, D. 151
Lluch-Cota, D.B. 151
Lorentzen, T. xi
Lu, H.-J. 219
McAllister, M.K. 152
MacCall, A.D. 128, 129, 131, 132, 147, 148, 151
McEvoy, A. 133
McFarlane, G.A. 129, 237
MacGarvin, M. 133
McGowan, J. 237
McKelvey, R. xi, 237, 240, 255, 258, 259
mackerel see horse mackerel;
Indo–Pacific mackerel; king mackerel; North Sea mackerel;
Paciﬁc mackerel
Malmberg, S-Aa. 69, 86
Målsøy 40
management procedure (MP) approach 152
Mantua, N.J. 237, 265, 299, 302
Markowitz, H.M. 31
Marr, J.C. 129, 147
Martin, W. 221
Martosobroto, P. 216
maximum sustainable yield (MSY) control rule 135–6

Mendelssohn, R. 265
Merton, R.C. 18, 21
migratory behaviour
Norwegian spring-spawning herring
67–9, 101–8
Pacific sardine 126
Miller, K. xi, 237, 258
Mirman, L.J. 236, 258
Misund, O.A. 262
mixed fisheries 302–3
models see Asian fisheries, climate change impact model; climate change impacts, modelling; Norwegian spring-spawning herring, game theory biomass model; South African pilchard/anchovy fishery model; Split Stream Harvest Model; worldwide system of small pelagic fisheries model, prototype
Moreno, I. de Leiva see de Leiva Moreno, I.
Mote, P.W. 265
MP (management procedure) approach 152
MSY (maximum sustainable yield) control rule 135–6
Mueller, D. 274
Mullon, C. xi–xii
Munro, G.R. 237
Myers, R.A. 152
Nagurney, A. 292
Namibian hake 211–13
Namibian pilchard biomass 205–6
consequences of decline 209–11
landings 205–6
reasons for decline 206–8, 213
NAO (North Atlantic Oscillation) 108, 238, 297
Neskaupstaður 101, 111, 113–14
North Atlantic Oscillation (NAO) 108, 238, 297
North Sea herring fishery 41, 50
migration dependant upon abundance 67
North Sea mackerel 36, 51–2, 55, 57, 61, 63
Norton, G. 221
Norway see Askøy; Bømlo; Fedje; Råkvåg
Norway pout fishery 58
Norway–EU fishing agreements 67
Norwegian fisheries
1919–1940 interwar period 37–42
1940–1960 postwar 43–4
1961+ crisis
adaptation 48–52
causes 47–8
consequences 44–7, 52–3
expansion in new fisheries 58–9
government response 53–4
regulation introduction 55–7
technology changes 54–5
and herring 34–6
Norwegian spring-spawning herring climate change impacts 85–8
data sources 78
definitions 36
game theory biomass model competitive solution, 81–4
cooperative solution 84–5
model 77–81
game theory literature 72–7
migratory behaviour 67–9, 101–8
Norway’s share 69–72
surplus growth model v. multi-year-class 88–98
NPV (net present value) calculation 201
NSSH see Norwegian spring-spawning herring
O’Brien, C. 297
Ocean Loop 67
ocean temperature changes as cause of Norwegian fisheries crisis 47–8
and collapse of Pacific sardine fishery 128
gradual 297–8
observed 33, 299
predictions 3, 300
see also East Iceland Current, cooling of; North Atlantic Oscillation; Pacific Decadal Oscillation
Ögmundardóttir, H. xii
optimum harvest policy
Pacific sardine fishery
catch allocation for full harvest utilization 139–44
harvesting capacity goal 138–9
limited entry 136–9
MSY control rule 135–6
policy considerations 144–7
Østvedt, O.J. 239
Ottersen, G. 238
Otterstad, O. xii–xiii, 118

Pacific Decadal Oscillation (PDO) 237–8
see also interdecadal variability
Pacific Fishery Management Council (PFMC) 128, 134, 145
Pacific mackerel 128, 132, 136, 219
see also Indo-Pacific mackerel
Pacific Northwest sardine fishery, climate change impacts 146–7
Pacific sardine (Sardinops sagax) climate change impacts 128, 129–31
Japanese demand 143–4
migratory behaviour 126
overview 126–8
Pacific sardine fishery
historical collapse 129–33
optimum harvest policy
catch allocation for full harvest utilization 139–44
harvesting capacity goal 138–9
limited entry 136–9
MSY control rule 135–6
policy considerations 144–7
renewal 133–5
Pacific–Atlantic correlations 120–22
Pardey, P. 221
Parma, A.M. 151, 152
Parsons, L.S. 238
Pascoe, S. 8
Pauly, D. 219, 263, 267, 292
PDO (Pacific Decadal Oscillation) 237–8
see also interdecadal variability
PFMC (US Pacific Fishery Management Council) 128, 134, 145
PFMC fishery management plan 128, 134
Philippines
climate change model results 227–9
see also Asian fisheries
pilchard 205
see also Namibian pilchard; South African pilchard/anchovy fishery model
Pindyck, R.S. 18, 21, 23, 24, 31
Plourde, C.G. 12
Potryagin, L.S. 22
pout see Norway pout fishery
Prato, T. 8
profitability, as feedback on fish stocks 36
Punt, A.E. 152
purse-seining 40, 45, 117, 132
Radovich, J. 126, 129, 131, 148
Råkvåg 114–20
regime shifts 151–2
Reiss, C. xii
resource depletion, reactions to 122–4
Roemmich, D. 237
Rogers, J.C. 238
Rosamond, N. 262
Roth, A.E. 268
saithe fishery 58–9
sand eel fishery 58
Sandal, L.K. 259
sardine see Pacific sardine; pilchard
Sardinops sagax see Pacific sardine
Schwartz, N.L. 18, 21
Schwartzlose, R.A. xvi
Schwing, F.B. 265
sea-net fishing gear 42
seine groups 40
seining see land-seining; purse-seining
Seyðisfjörður 101–2, 111, 113–14
Shannon, L.J. 205
Shoven, B.J. 268
Siglufjörður 101–2, 108–12
Sigurðsson, B. 102, 109
Silvestre, G.T. 216, 218
Sissener, E.H. 76
Sjurseth, K. 114
small herring fishery 36–7, 41
Smith, A.D.M. 152
Snyder, M.A. 265
Soutar, A. 155
South African pilchard/anchovy fishery model
discussion 193–6
interannual catch variability 187–92
management procedures alternatives 163–4
estimators 157–63
sources of 156
NPV v. loss results 177–87
operating models 152–5
preliminary investigations 165–70
without Total Allowable Catch constraints 192–3
summary performance statistics 155–6

Sparre, P.J. 196
Split Stream Harvest Model
elements of output 243–53
further advances 255–9
information structure of game 242–3
overview 239–40
sprat fishery 41–2, 49, 58
spring herring fishery 36–7, 39
Stavanger 40
Steinshamn, S.I. 211, 259
Stenevik, E.K. 33, 48, 300
Stenseth, N.C. 237, 238
Stephanus, K. xiii
Storsilsfisket see big herring fishery
Sumaila, U.R. xiii–xiv, 211
Sundby, S. 33, 48, 300
Supongpan, M. 217
supplementary occupations of fishers 42
see also alternative occupations of fishers
supply-demand models 268–9
Sutinen, J.G. 302

Tacon, A.G.J. 273
technology changes 36, 54–5, 61–2, 63
teleconnections see Atlantic–Pacific correlations
Thailand
climate change model results 229–31
see also Asian fisheries
Toresen, R. 239

Trinidad, A. 217, 218
Troade, J.-P. 263
Tsai, C.-F. 219
Tufteland, J. 114
tuna fishery off Norway, disappearance of 50
Tvetetar, R. 273

Uber, E. 128, 129, 132, 147
US Pacific Fishery Management Council (PFMC) 128, 134, 145

Van Loon, H. 238
Vårsilsfiske see spring herring fishery
Vasconcellos, M. 211
Vilhjálmsen, H. 86, 98, 101, 103, 108
Vivekanandan, E. 217
Vollan, O. 114
Vrooman, A.M. 126

Walden, J.B. 138
Walters, C.J. 151, 152, 272
Watson, R. 263, 267, 292
Weeks, S.J. 262
Welch, D.W. 297
Whalley, J. 268
Wilen, J.E. 16
Willmann, R. 196
winter capelin fishery 57–8
winter herring fishery 36–7, 39–40, 41, 43–4
see also big herring fishery; spring herring fishery
worldwide system of small pelagic fisheries model, prototype
data collection 278
discussion 290–92
entities, scales and mechanisms 269–74
modelling principles 267–9
overview 262–7
parameters 274–6
results 281–6
role-playing game 276–7
scenarios 276
‘black’ 281–6
‘pink’ 286
sensitivity analysis 276, 286
zonal attachment 66–7