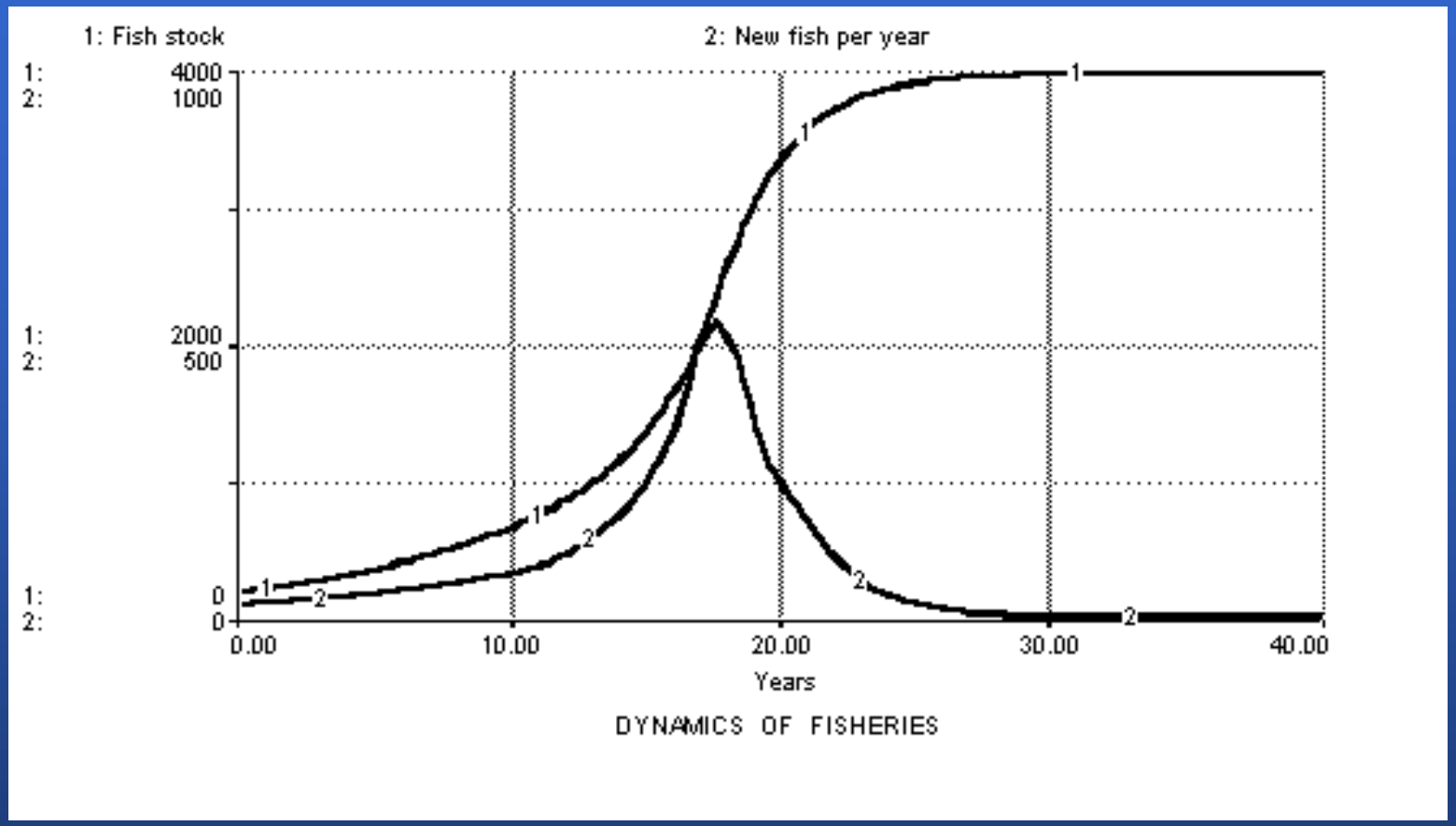
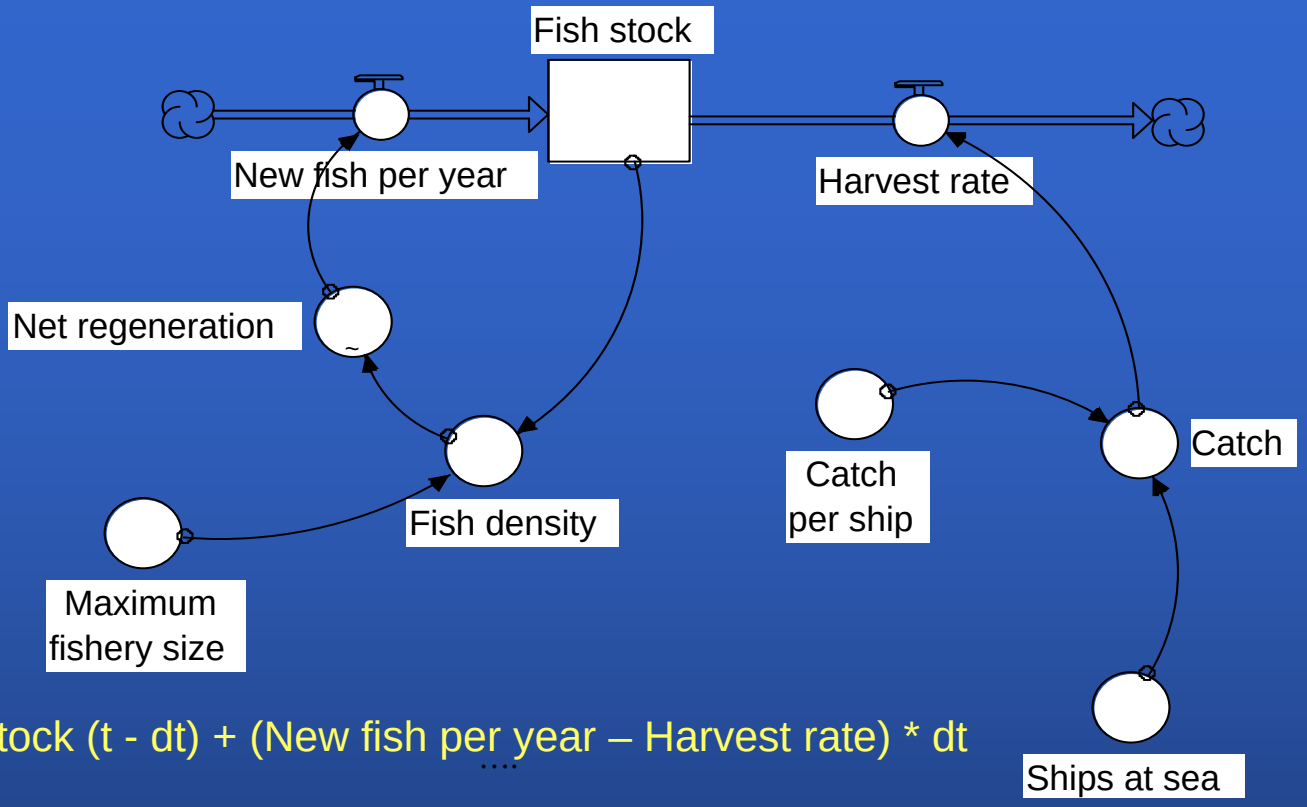


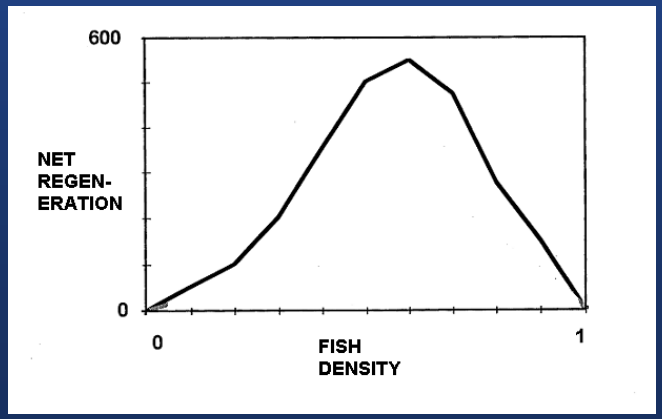

Figure 9.16 Simulation of a Natural Fishery with an Initial Population of 200 Fish and Maximum Fishery Size of 4000

# Figure 9.17 A Simple Harvested Fishery




Fish stock (t) = Fish stock (t - dt) + (New fish per year – Harvest rate) * dt
INIT Fish stock = 200
New fish per year = Net regeneration
Net regeneration = GRAPH (Fish density) (0, 0), (0.1, 50), (0.2, 100), (0.3, 200), (0.4, 320), (0.5, 500), (0.6, 550), (0.7, 480), (0.8, 300), (0.9, 180), (1, 0)
Fish density = Fish stock / Maximum fishery size
Maximum fishery size = 4000

Harvest rate = Catch {fish/year}
Catch = Ships at sea * Catch per ship {fish/year}
Catch per ship = 25 {fish per ship per year}



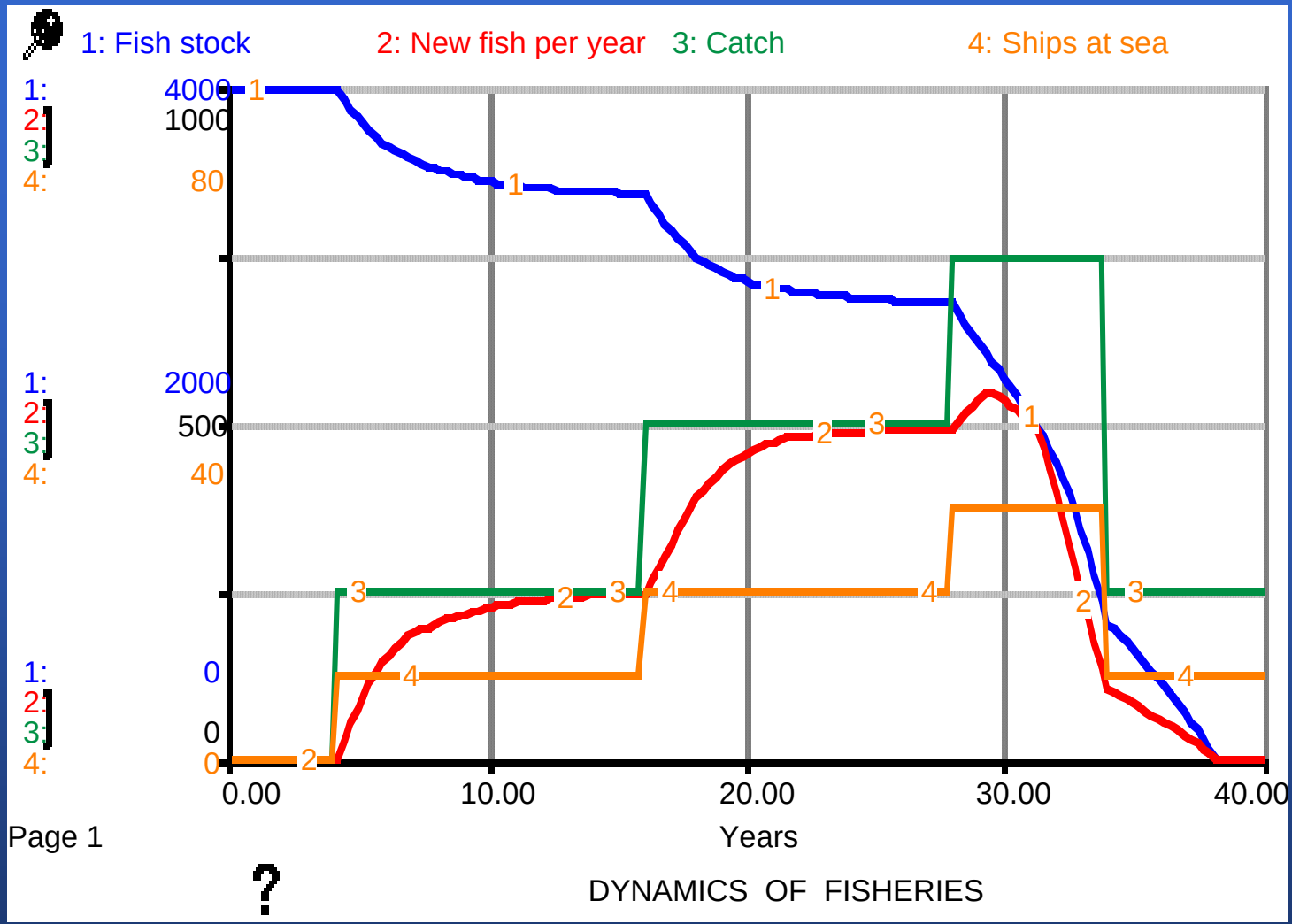
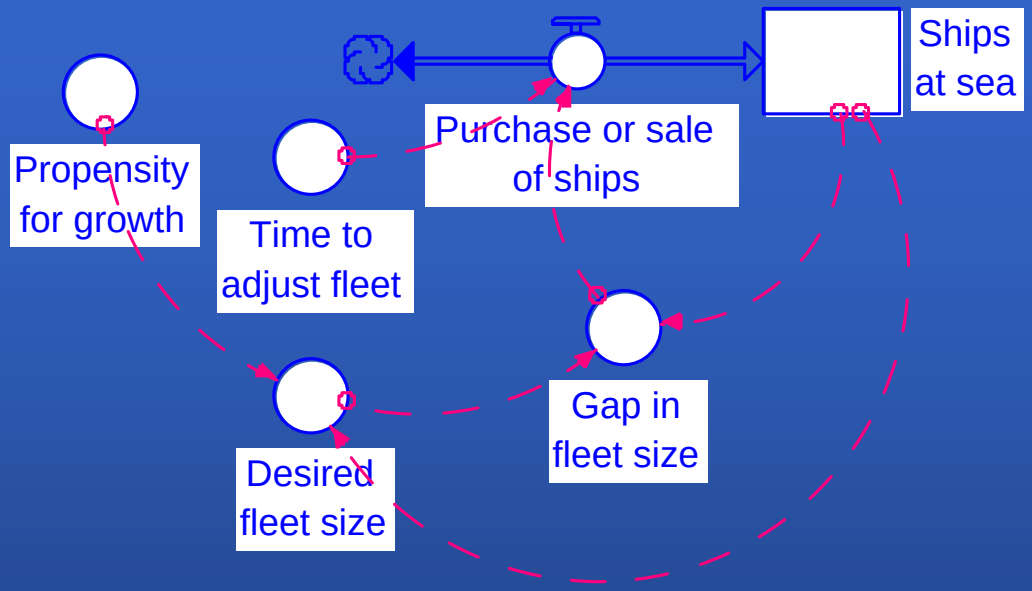


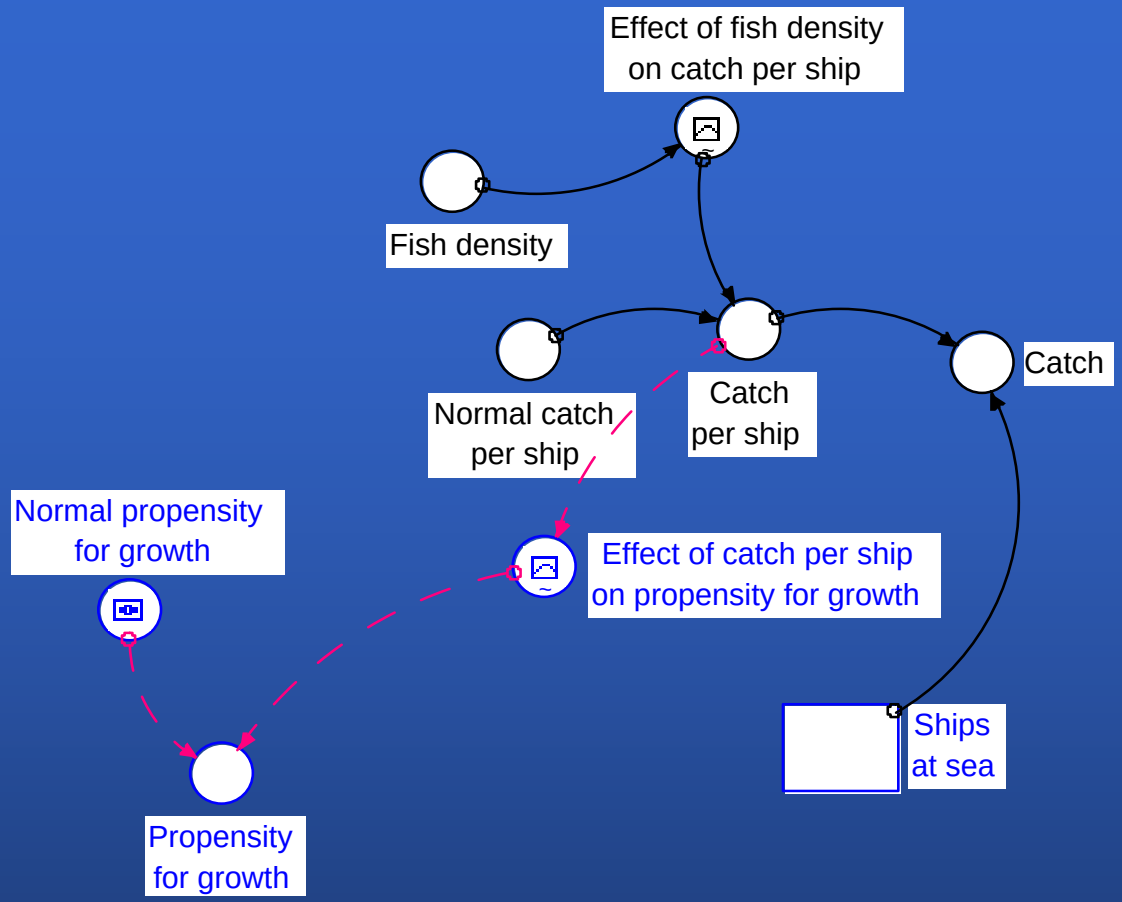

Figure 9.18 Simulation of a Harvested Fishery with Stepwise Changes in Fleet Size

# Figure 9.19
# Fleet Adjustment in a Harvested Fishery




Ships at sea (t) = Ships at sea (t - dt) + (Purchase or sale of ships) * dt
INIT Ships at sea = 4 {ships}
Purchase or sale of ships = Gap in fleet size/Time to adjust fleet {ships/year}
Gap in fleet size = Desired fleet size – Ships at sea {ships}
Desired fleet size = Ships at sea * (1 + Propensity for growth) {ships}
Propensity for growth = …. See figure 10.20 for this important formulation, for now just assume that normally the propensity for growth is positive and non-zero
Time to adjust fleet = 1 {year}

# Figure 9.20 Formulation of Propensity for Growth and Catch per Ship




Catch = Ships at sea * Catch per ship {fish/year}
Catch per ship = Effect of fish density on catch per ship * Normal catch per ship {fish per ship/year}
Normal propensity for growth = .1 {fraction}
Propensity for growth = Normal propensity for growth * Effect of catch per ship on propensity for growth
Effect of catch per ship on propensity for growth = GRAPH (Catch per ship)
(0.00, -0.48), (2.50, -0.45), (5.00, -0.37), (7.50, -0.27), (10.0, 0.00), (12.5, 0.64), (15.0, 0.9), (17.5, 0.995), (20.0, 0.995), (22.5, 1.00), (25.0, 1.00)
Effect of fish density on catch per ship = GRAPH (Fish density)
(0.00, 0.00), (0.1, 0.4), (0.2, 0.68), (0.3, 0.8), (0.4, 0.88), (0.5, 0.96), (0.6, 1.00), (0.7, 1.00), (0.8, 1.00), (0.9, 1.00), (1, 1.00)

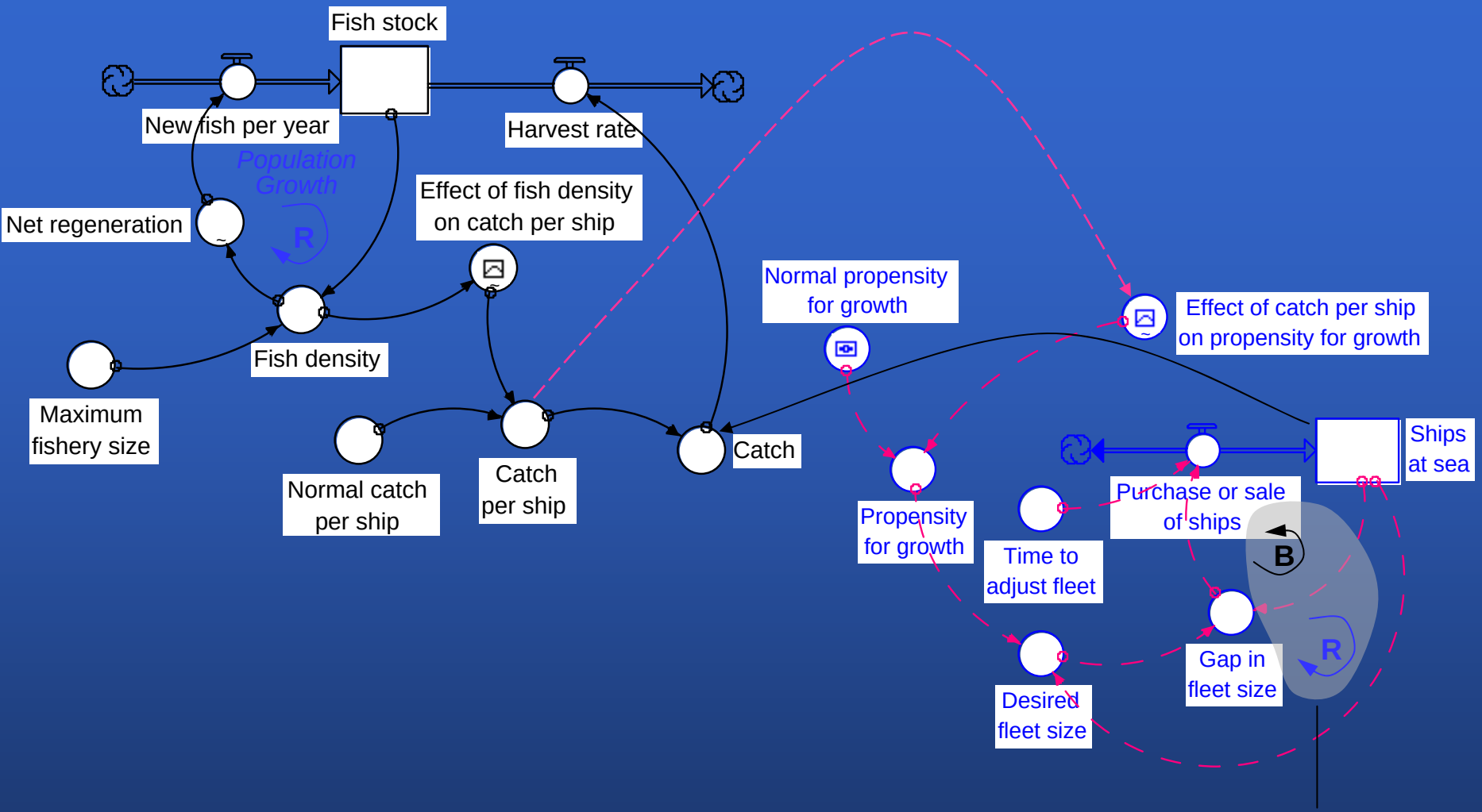



Figure 9.21 Overview of a Simple Fisheries Model with Endogenous Investment

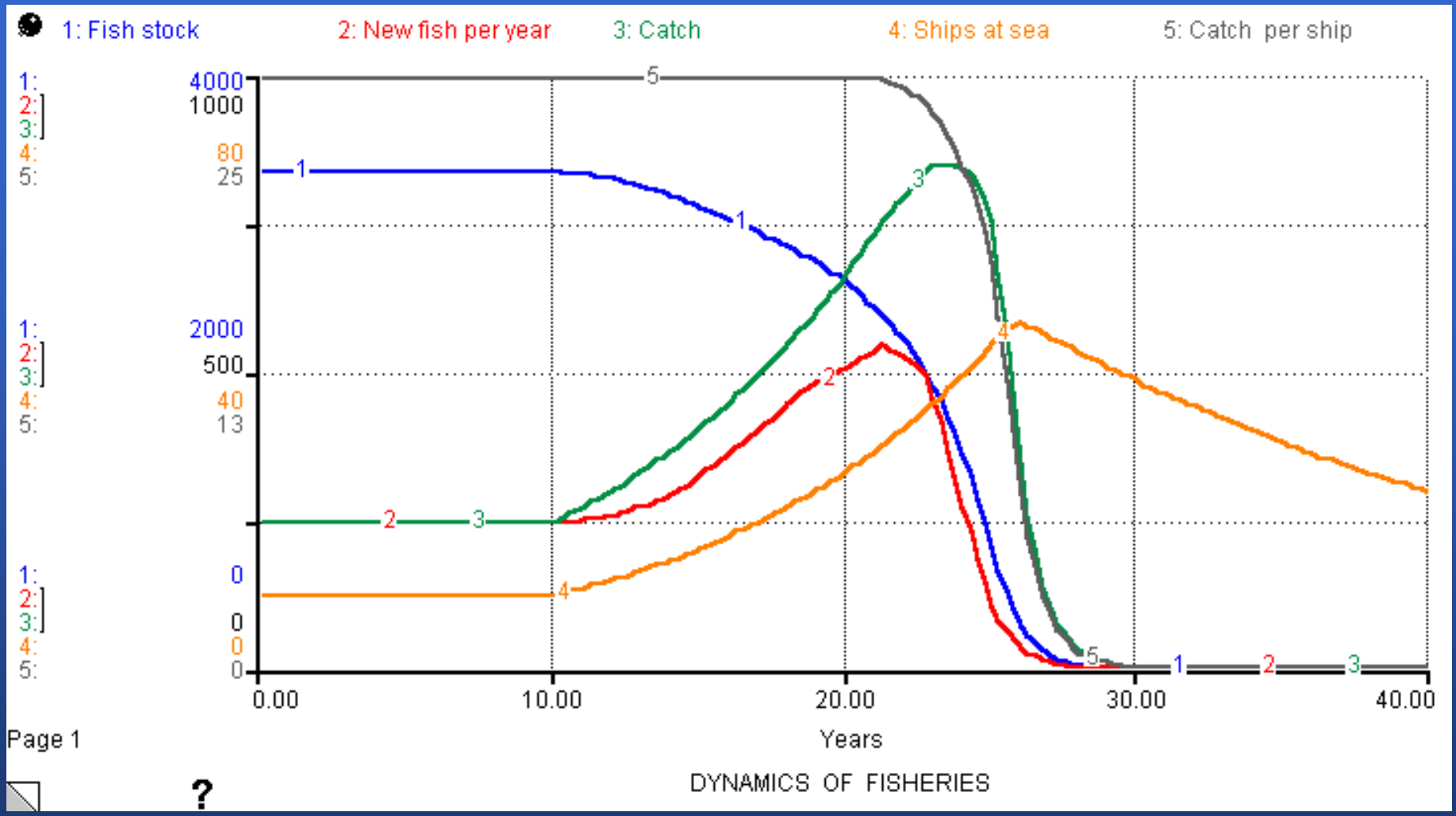



Figure 9.22 Simulation of a Fishery that Starts in Equilibrium, Grows with Investment and then Unexpectedly Collapses

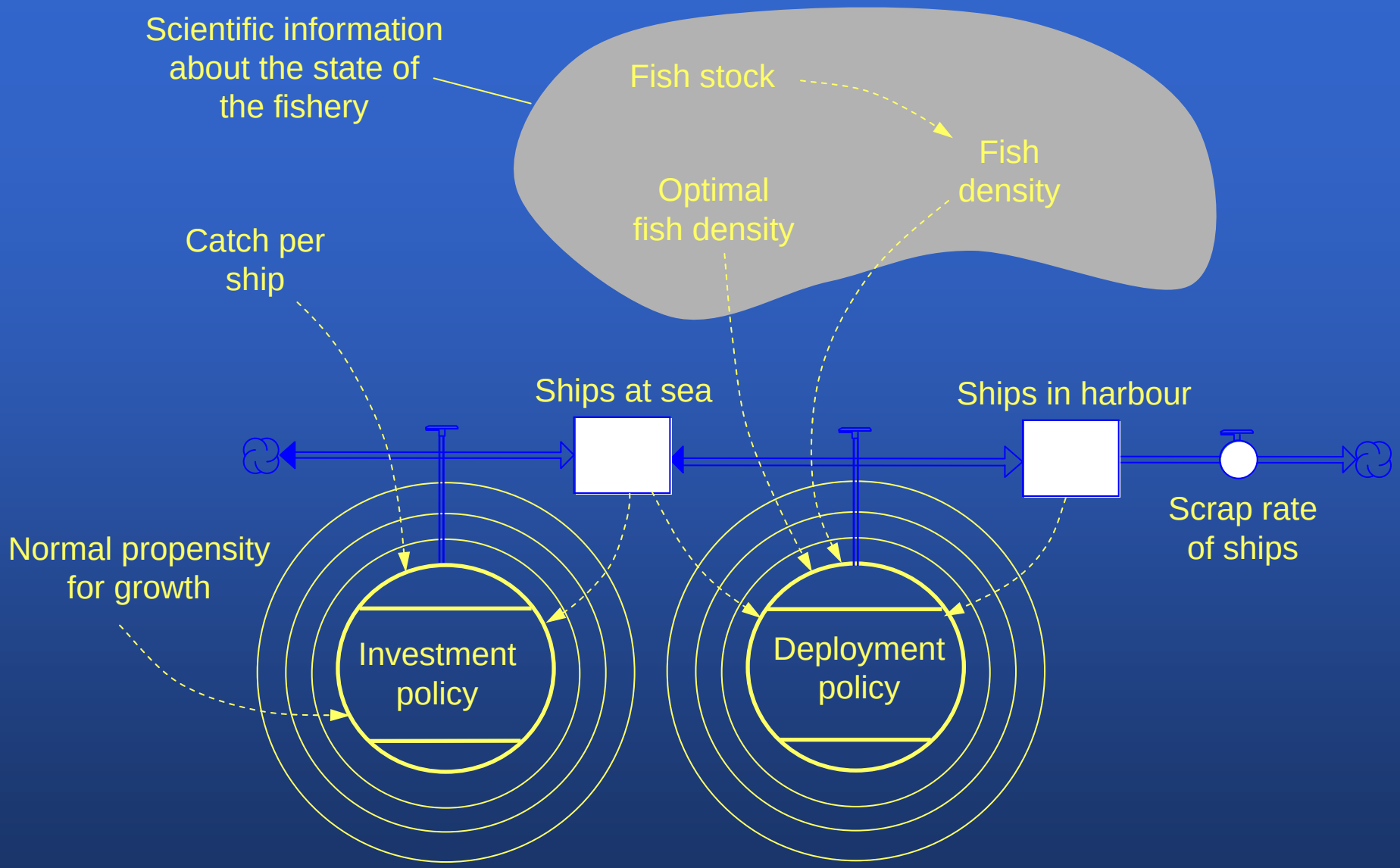



Figure 9.23 Policy Design in Fisheries

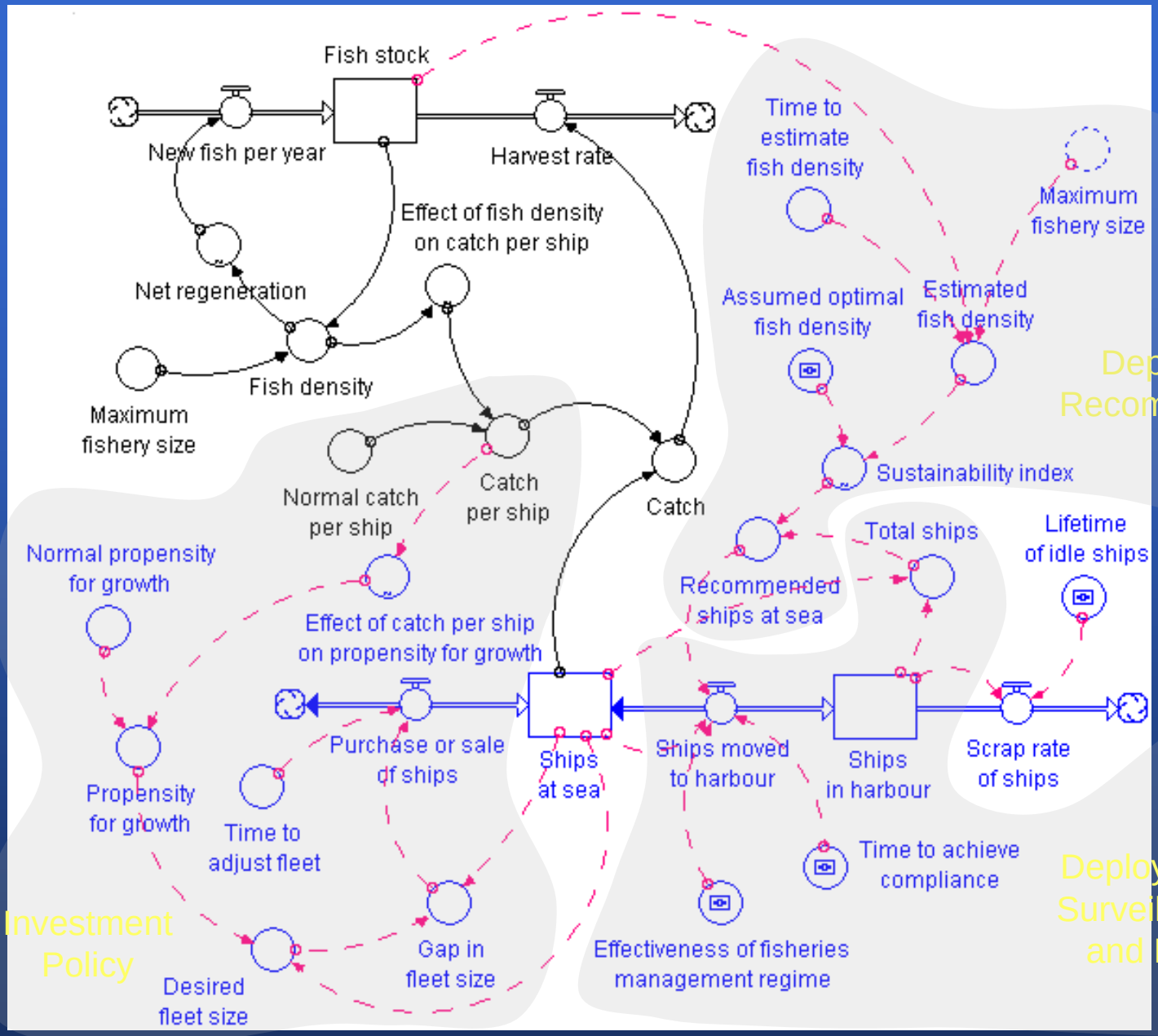



Figure 9.24 Overview of Fisheries Policy Model

## Recommended Fleet Size

Recommended ships at sea = Total ships * Sustainability index {ships}
Sustainability index = GRAPH (Estimated fish density / Assumed optimal fish density)
(0.00, 0.00), (0.1, 0.00), (0.2, 0.00), (0.3, 0.00), (0.4, 0.005), (0.5, 0.03), (0.6, 0.1), (0.7, 0.3), (0.8, 0.76), (0.9, 0.92), (1, 1.00), (1.10, 1.00), (1.20, 1.00)
Estimated fish density = SMTH1(Fish stock / Maximum fishery size, Time to estimate fish density) {dimensionless}
Maximum fishery size = 4000 {fish}
Time to estimate fish density = 0.5 {years}
Assumed optimal fish density = 0.6 {dimensionless}

## Surveillance of Ships and Enforcement

Ships moved to harbour = (Ships at sea – Recommended ships at sea) * Effectiveness of fisheries management regime / Time to achieve compliance {ships/year}
Total ships = Ships at sea + Ships in harbour {ships}
Effectiveness of fisheries management regime = 1 {dimensionless}
Time to achieve compliance = .5 {years}

## Ships at Sea, Ships in Harbour and Scrap Rate

Ships at sea(t) = Ships at sea(t - dt) + (Purchase or sale of ships – Ships moved to harbour) * dt
INIT Ships at sea = 10 {ships}
Ships in harbour(t) = Ships in harbour(t - dt) + (Ships moved to harbour – Scrap rate of ships_) * dt
INIT Ships in harbour = 0 {ships}
Scrap rate of ships = Ships in harbour / Lifetime of idle ships {ships/year}
Lifetime of idle ships = 5 {years}

Figure 9.25 Equations for Deployment Policy and Ships