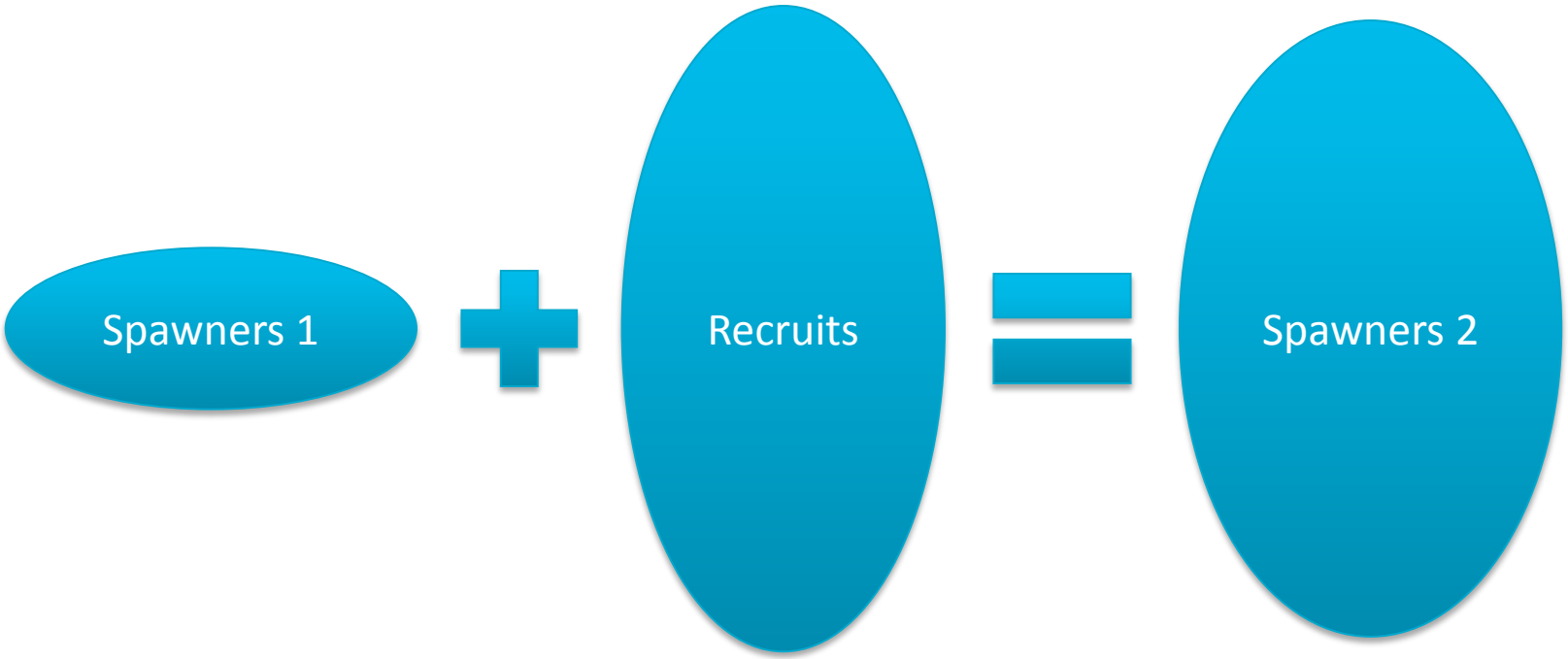
Population dynamics: Introduction

Kaohsiung, Taiwan, 16 December 2016

Spawning stock biomass (SSB)

- Reproductive component of the stock
- Influences future abundance and sustainable yield:
  - Directly, through abundance and catch of mature fish
  - Indirectly, through production of recruits = ***"Stock-Recruitment Relationship"***
- Rationale for Limit Reference Point for SSB.



Limit Reference Point - SSB

- Limit Reference Point
  - *an undesirable state that is to be avoided with a high probability*.
- In the context of Spawning Stock Biomass, Limit Reference Points are defined to:
  - *Reduce the probability of declines in the productivity of the stock*

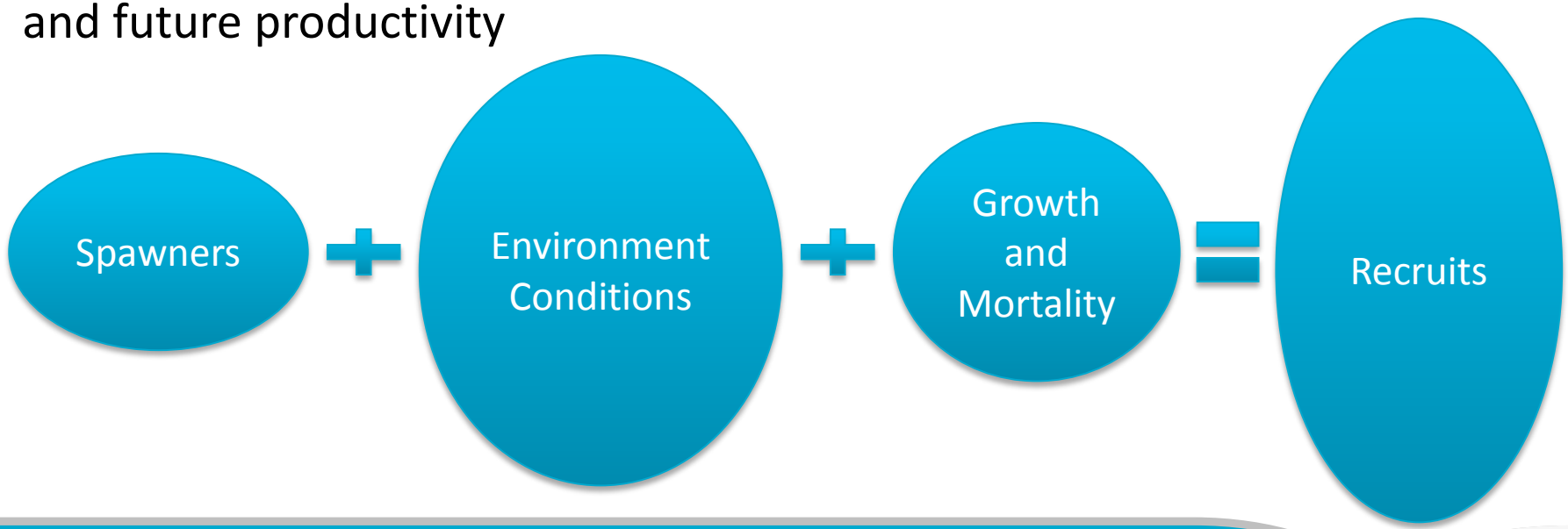
or, more specifically:

  - *reduce the probability of the spawning stock being depleted to a level where average recruitment declines over the medium to long term.*

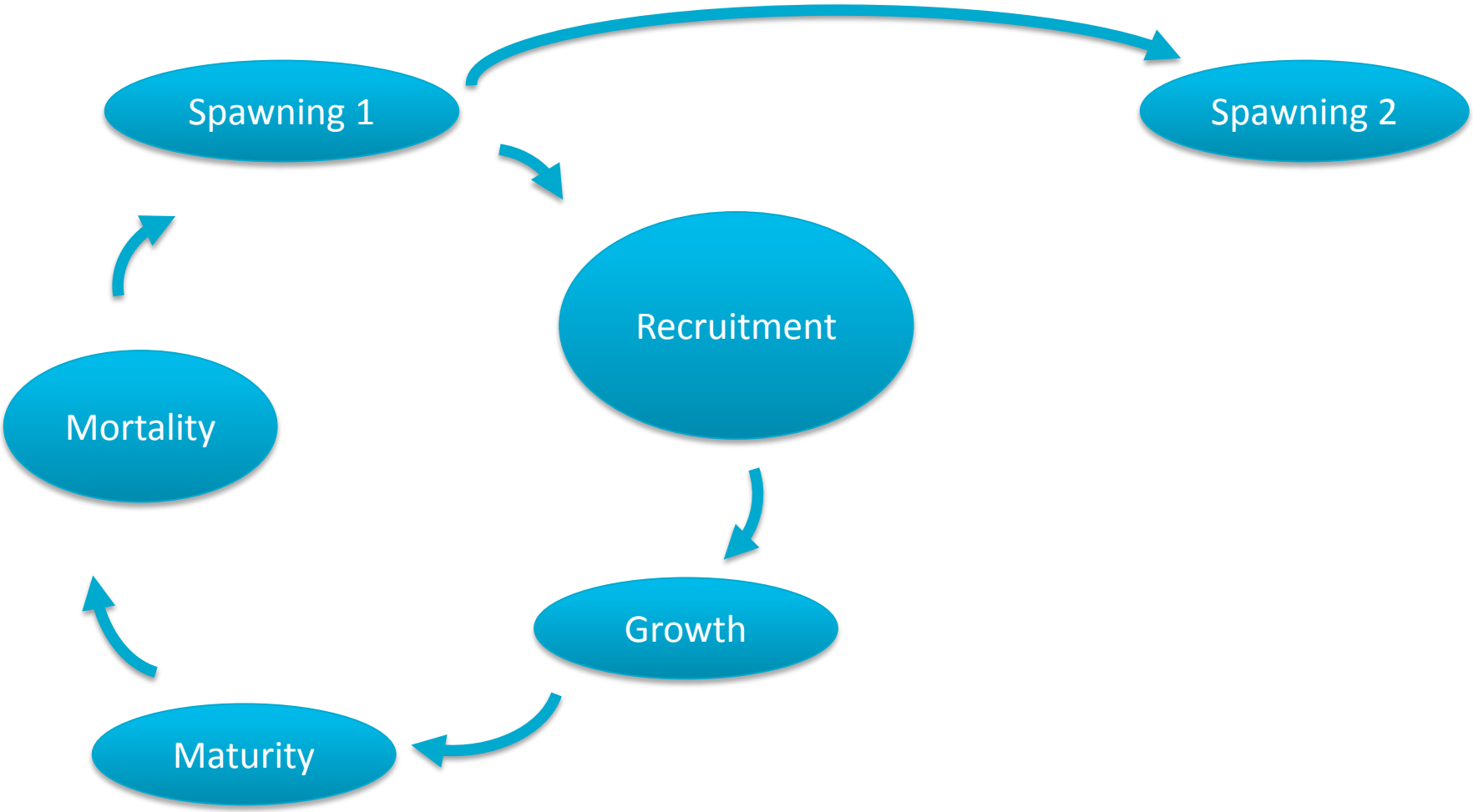
Hence, effective harvest strategies are designed to progressively reduce fishing mortality as a LRP is approached to avoid depleting the reproductive component of the stock (SSB) below a pre-specified level.

Stock-Recruitment relationship

- Stock-Recruitment relationship very uncertain for most tropical tuna
  - **Recruitment:** includes processes of “birth, growth and natural mortality“ of new fish into the fishery relative to spawning stock size
  - naturally highly variable (process uncertainty)
  - Measurement of recruitment has high uncertainty (observation uncertainty)
- Stock-Recruitment relationship very influential in estimates of current and future productivity



Population Dynamics cycle



Growth & Mortality

- ***Growth*** or, more specifically, somatic growth is important for a number of reasons:
  - Relating size to age of fish and longevity
  - Determining how long it takes fish to mature and "recruit" to the fishery
  - Determines the life-time reproductive output

- ***Natural mortality*** **(M)** determines the proportion of each year-class (cohort) that survive to grow and reproduce the following year, and be available to the fishery to catch.

- ***Fishing mortality*** **(F)** is the proportion of fish removed by the fishery in one year. Ideally this includes all (total) removals, not just those landed/reported as catch.

Productivity and sustainable yield

- Productivity of a fish stock is determined by:
  - Rate of growth (recruitment and somatic growth)
  - Rate of mortality (natural mortality (M) + fishing mortality (F))

- The sustainable yield, in principle, is the largest average catch that can be taken, over the long-term, without reducing the reproductive potential of the stock.

- In reality, the sustainable yield, will vary over time due to:
  - The historical development of the fishery and the current state of the stock
  - The particular mix of gears used in the fishery, as this determines the selectivity and fishing mortality from a given level of effort from the current fleet structure
  - Long-term cycles in ocean productivity &/or regime shifts

Limit Reference Point – Fishing Mortality

Fishing at Maximum Sustainable Yield – F_{MSY}

- **F_{MSY}** is, in principal, the level of fishing mortality that would, on average, result in the maximum long-term catch and reduce the stock to **B_{MSY}**
  - with constant average recruitment, for a given overall selectivity.

- **F_{MSY}** is recommended a a limit reference point for fishing mortality, as experience has shown that fishing at, or above, this level can result in stocks being overfished and depleted to levels that reduce long-term productivity.

- This results in substantial rebuilding times and forgone catches, with associated economic and social costs.

Reality of fisheries science and management

Fisheries are dynamic, uncertain systems

- Fisheries systems are more complicated, variable, dynamic and difficult to observe and predict
- Understanding is incomplete and advice is uncertain

Inertia

- Past events and decisions impact on the future states of the stock and fishery
- Uncertainty in advice makes it difficult to take decisive action.

Multiple objectives and consensus decision making

- No single optimal objective for fisheries management
- Decisions require trade-offs across social and economic dimensions and risk to the stock productivity
- The international dimensions of tuna fisheries increase the complexity of the decision making