Estrategias de explotacion
Puntos de referencia

Principios básicos

Objetivos de manejo

Sociales (e.g. empleo, acceso a alimentación)
Económicos (e.g. rentabilidad)
Biológicos (e.g. riesgo de colapso)
Ecosistema (e.g. bycatch, diversidad)
Políticos (e.g. distribución de oportunidades de pesca)

Biología

Métricas de desempeño

Especificados por administración

e.g. captura total
variabilidad de capturas
tasa de captura
probabilidad de colapso

Puntos de referencia objetivo

Especificados por administración

e.g. x%B_{MSY}
x%F_{MSY}
MEY, CPUE, etc

Puntos de referencia límite

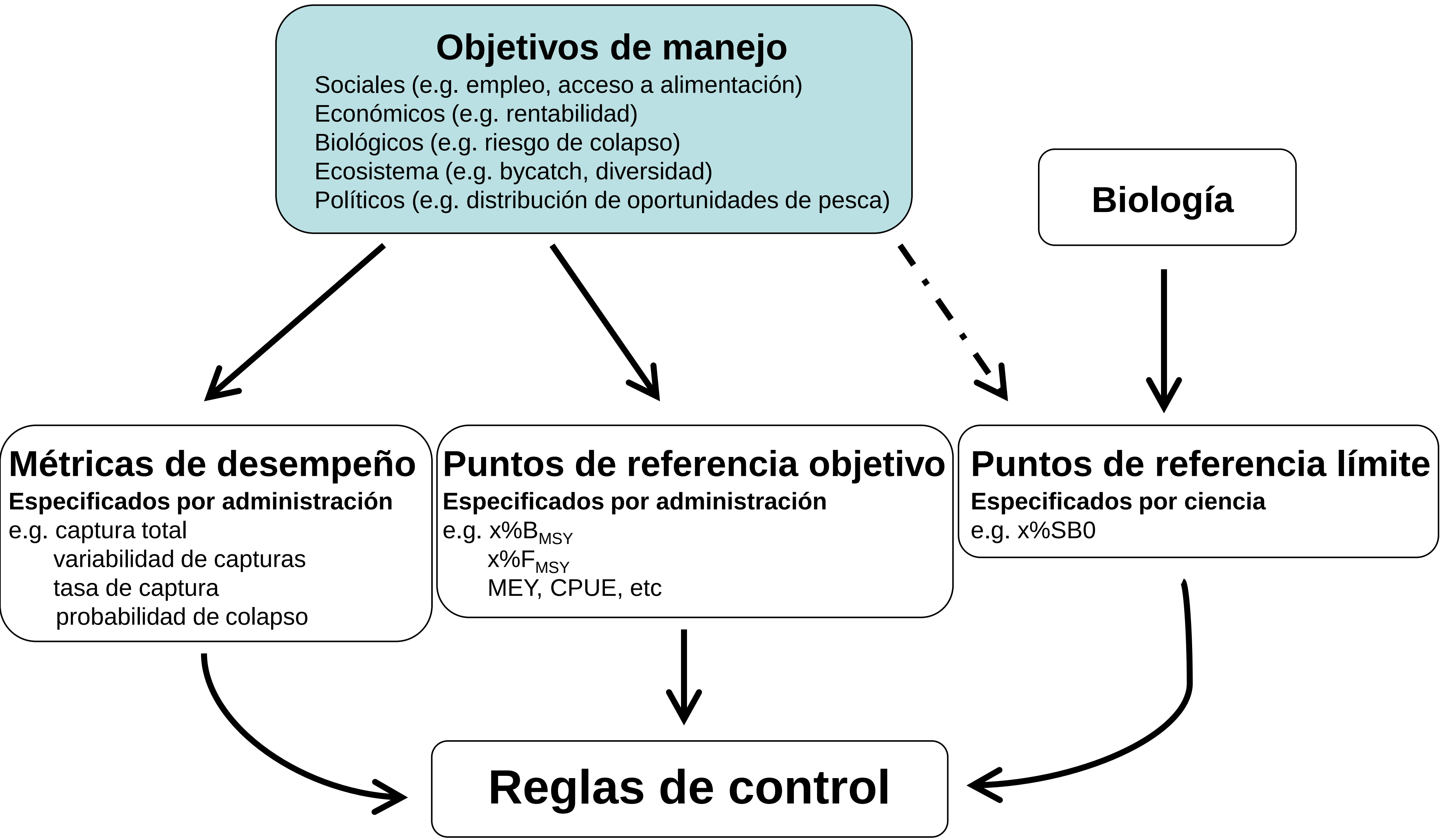
Especificados por ciencia

e.g. x%SB0

Reglas de control

Modificado de Berger et al. 2012

Principios básicos



Modificado de Berger et al. 2012

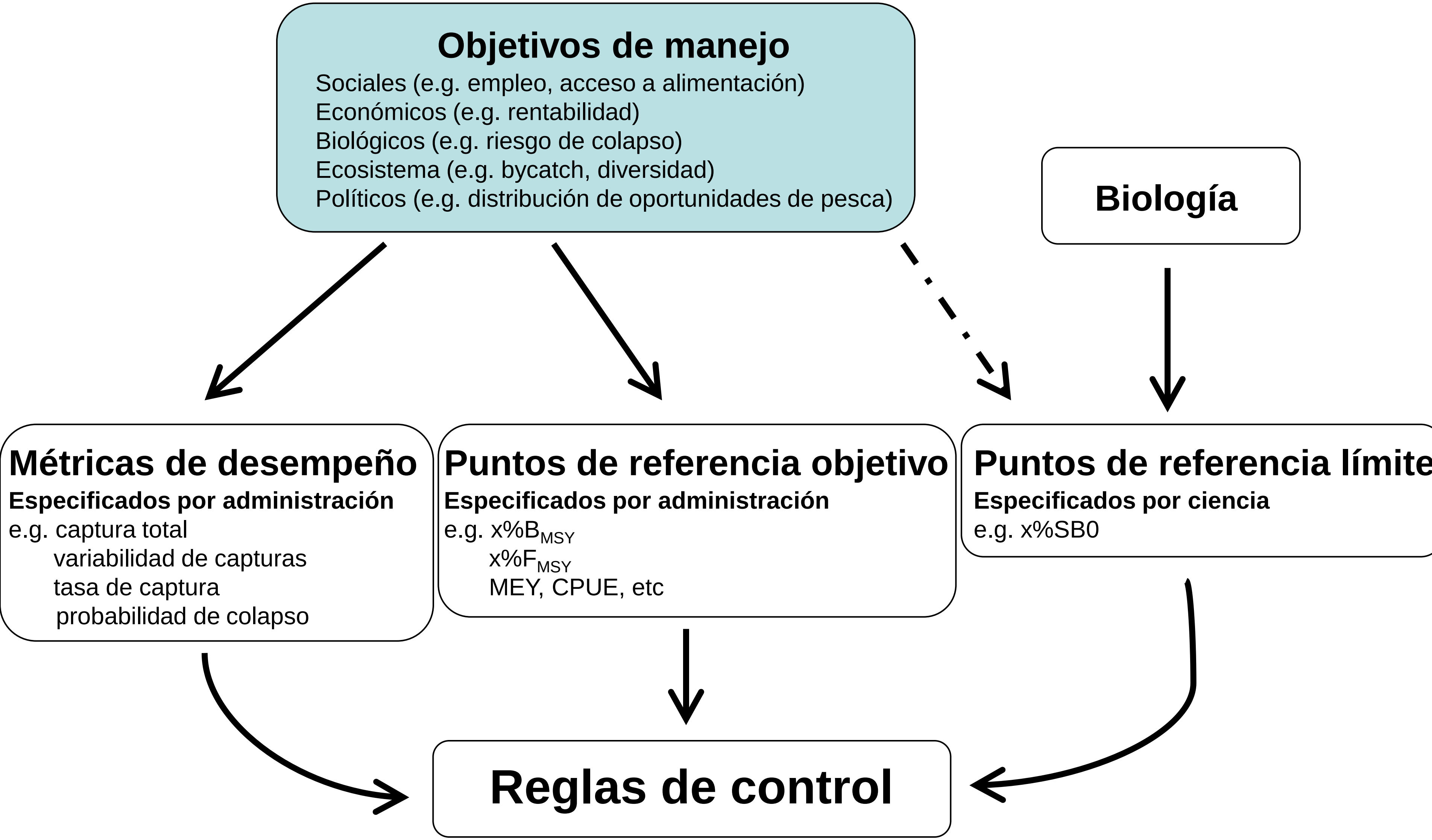
Objetivos de manejo

- Describen de manera explícita, específica e inequívoca los objetivos
  - Sociales (e.g. empleo, acceso a alimentos)
  - Económicos (e.g. rentabilidad)
  - Biológicos (e.g. riesgo de colapso)
  - Ecosistema (e.g. bycatch, diversidad)
  - Políticos (e.g. distribución de oportunidades de pesca)

Objetivos de manejo

- Claros objetivos de manejo son criticos para establecer puntos de referencia y para definir el desempeño de la estrategia de explotación
- No deben ser vagos (discutir ejemplos)
- Deben contener específicos:
  - Cuantidades
  - Probabilidades
  - Plazos previstos

Principios básicos



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e.g. x%SB0

Reglas de control

Modificado de Berger et al. 2012

Medidas de desempeño, variables de interés

- Long-term total catch
- Long-term average catch
- Long-term variability in catch
- Short-term catch
- Short-term variability in catch
- Probability *(P)* of dropping below reference points
- *P* stock rebuilding
- Average long-term CPUE
- average long-term effort
- MANY MORE!

Medidas de desempeño, balances y sacrificios

- average long-term catch & average long-term CPUE
- average long-term catch & *P* below reference points
- average long-term catch & short-term catch
- average long-term CPUE & annual CV catch
- average long-term effort & *P* stock rebuilding

Riesgo

- Medidas de riesgo
  - Probabilidad de sobrepesca
  - Probabilidad de colapso (económico o biológico)
  - Probabilidad de clausuras temporales o espaciales
- Tipos de comportamiento al riesgo
  - Aversión (tendencia a evitar riesgo)
  - Propenso (tendencia a preferir riesgo)
  - Neutro (indiferente al riesgo)

Principios básicos

Objetivos de manejo

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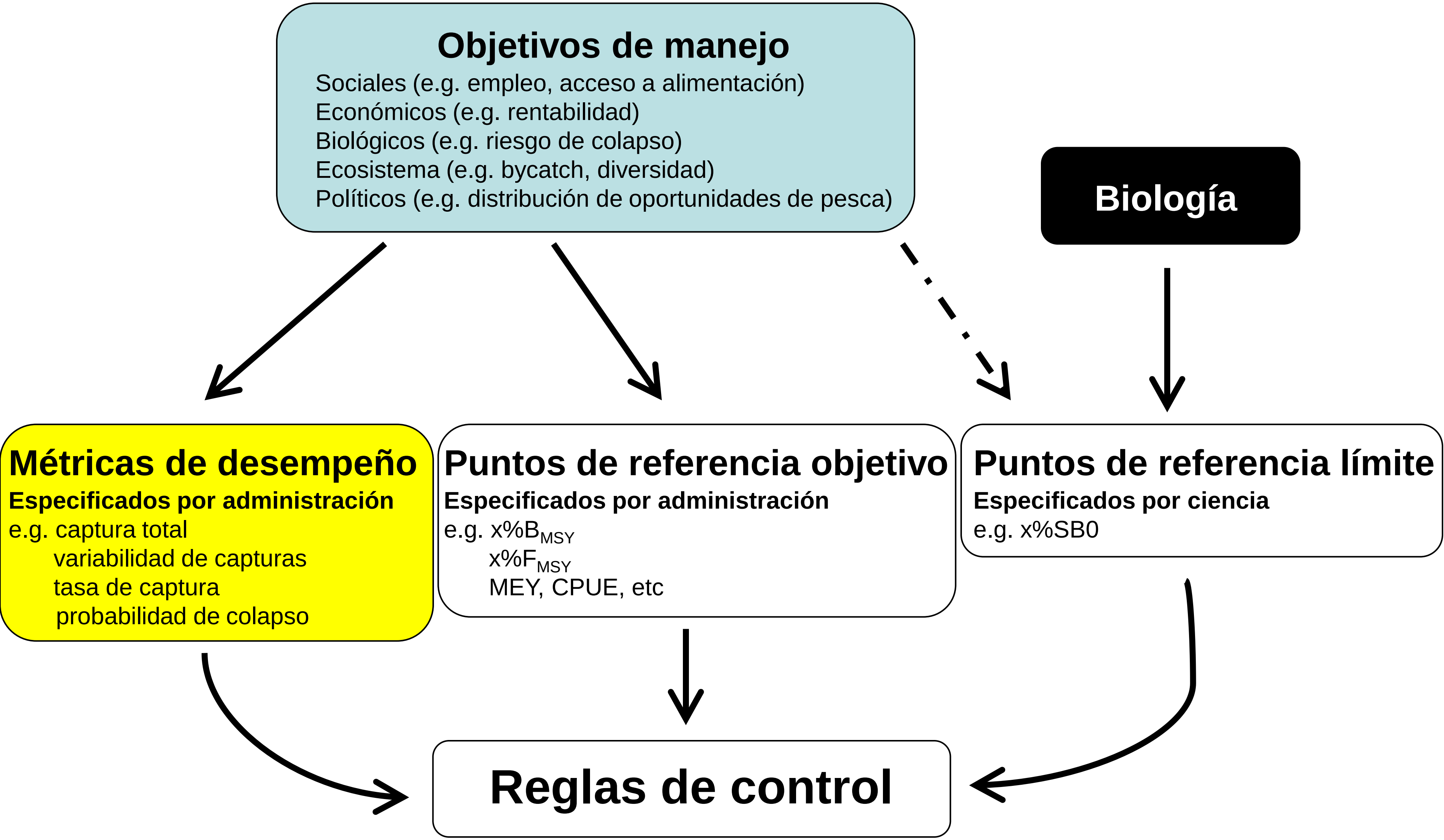

Modificado de Berger et al. 2012

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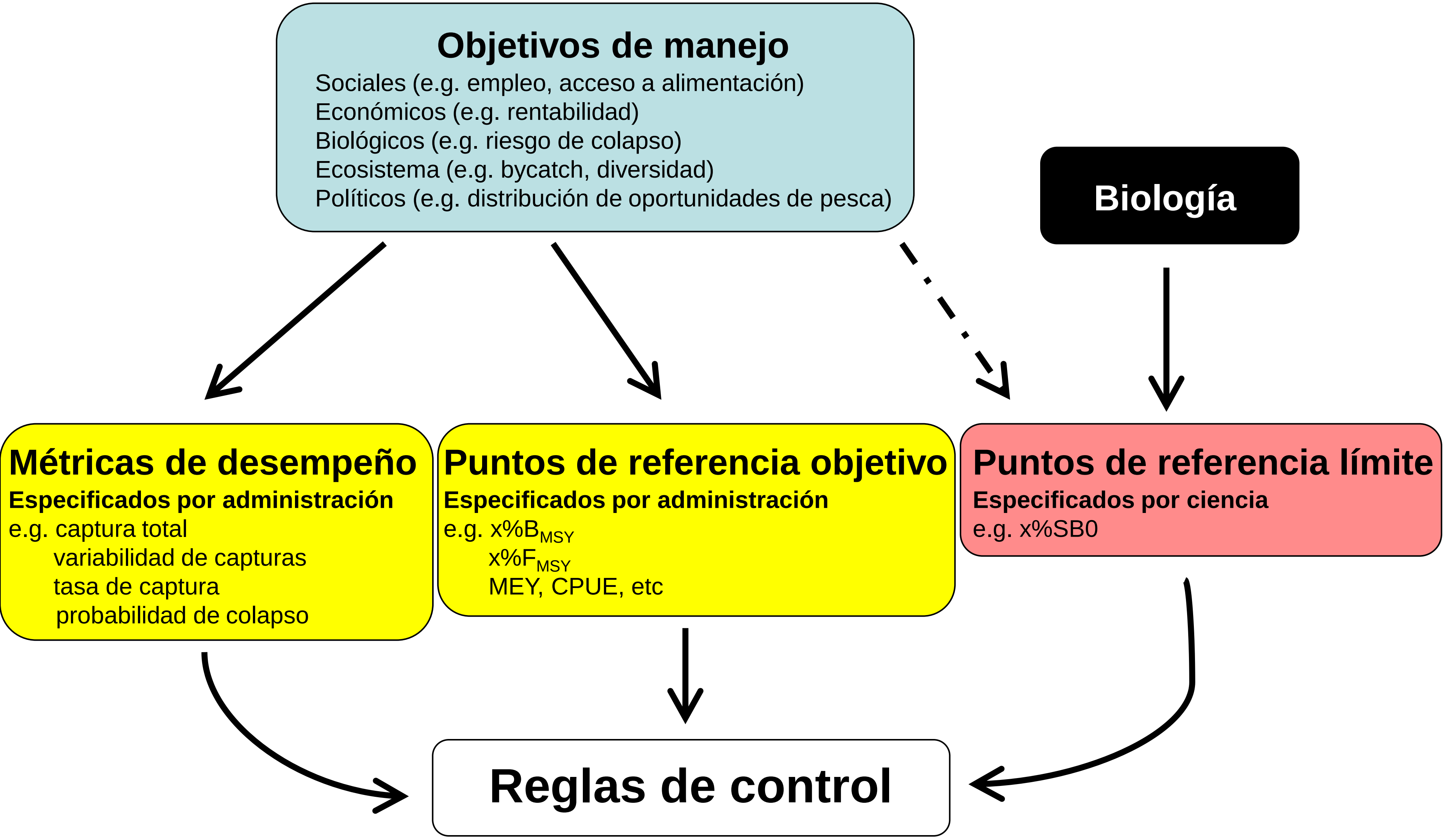


Modificado de Berger et al. 2012

Puntos de referencia

- Guidelines for management. Benchmarks against which the abundance of the stock, the fishing mortality rate or economic and social indicators can be measured to determine its status.

Puntos de referencia

- **Limit Reference Point:** A benchmark that should not be exceeded with any substantial probability according to a given set of management objectives. Beyond this limit the state of a fishery is not considered desirable and remedial management action is required. When a stock is at very low abundance, they are often taken as interim rebuilding targets and/or trigger fishery closures.

Puntos de referencia

- **Threshold Reference Point:** indicates that biomass has fallen below the target, or fishing mortality has increased above its target, to the extent that additional management action may be required in order to prevent the stock from declining further and possibly breaching the limit.

Puntos de referencia

- **Target Reference Point:** A benchmark that should be achieved on average according to a given set of management objectives. It corresponds to a state of a fishery and/or a resource which is considered desirable.

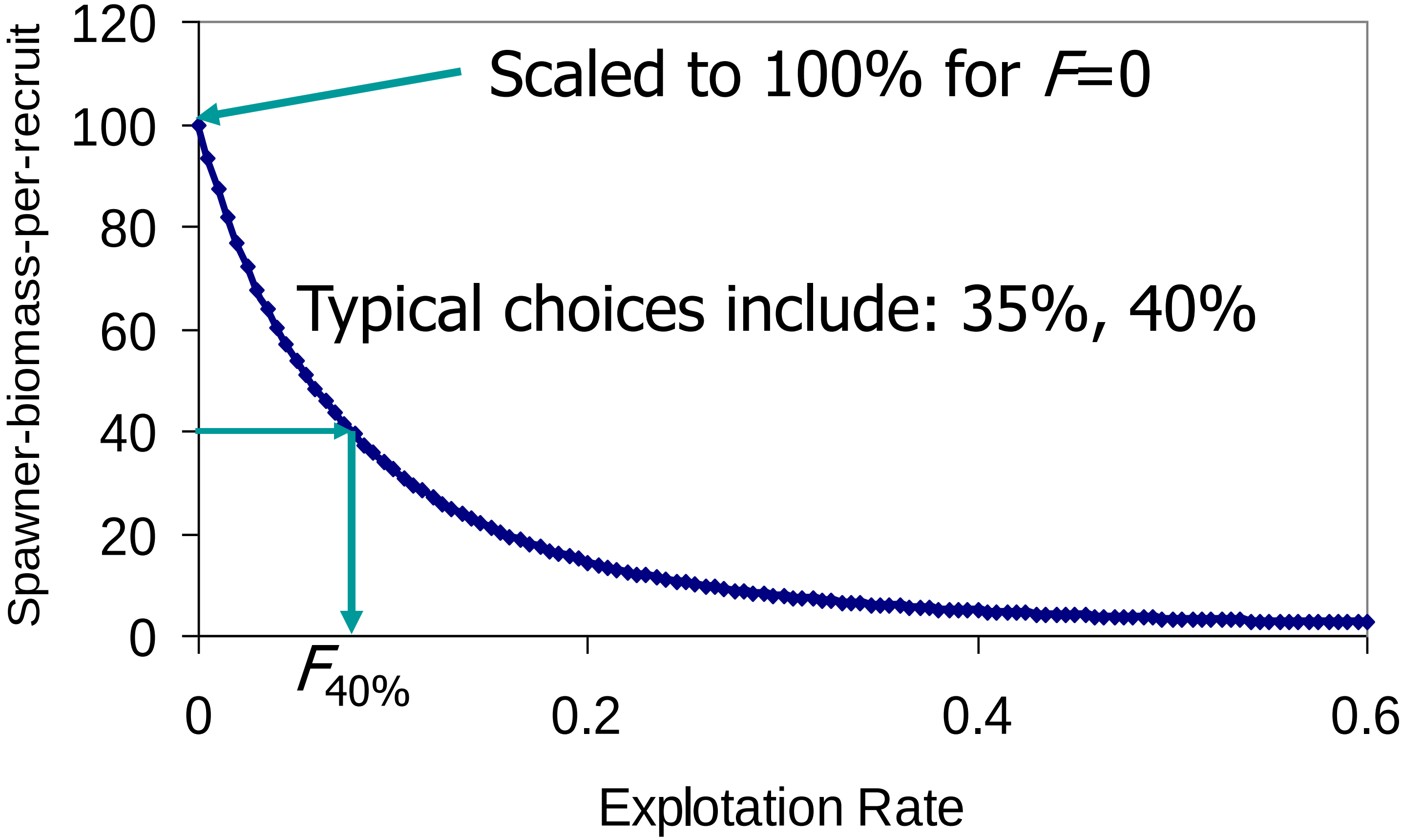
Puntos de referencia

- **Limit Reference Point**
- **Threshold Reference Point**
- **Target Reference Point**

Puntos de referencia

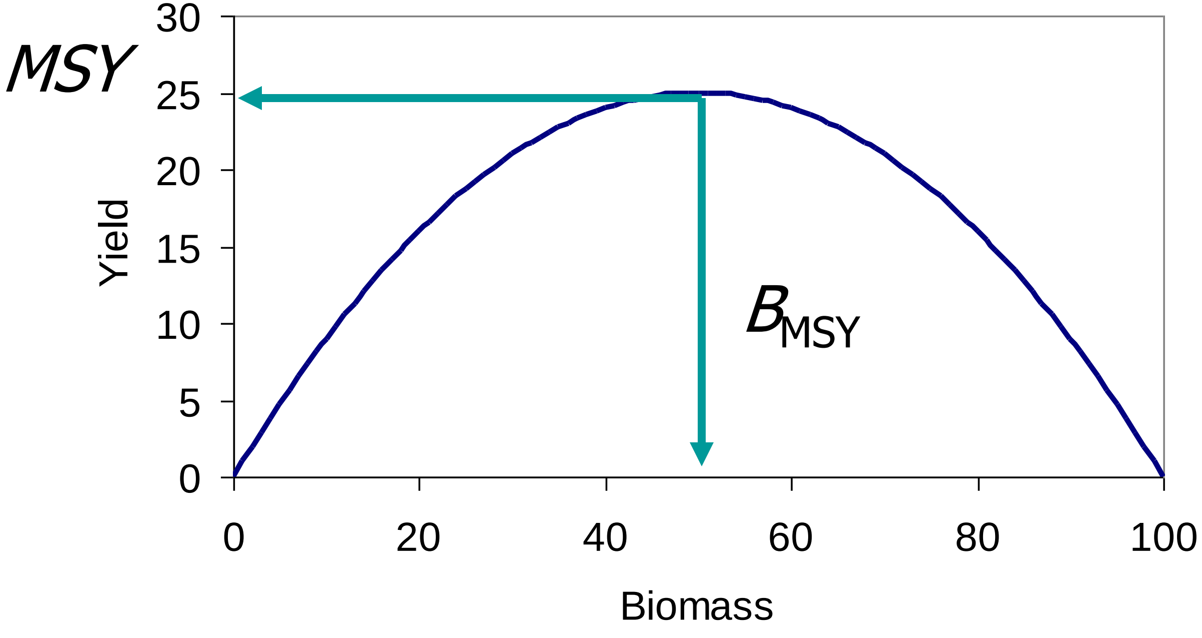
- May be based on exploitation rates or on biomass
- F_{MSY} and B_{MSY} based on **stock-recruit relationships**
- B_{MEY} based on **economics**
- F_{max}, $F_{0.1}$, $F_{35\%}$, $F_{40\%}$ based on **per-recruit** (assumes recruitment independent of stock size)

Spawner Biomass-per-Recruit Reference Points



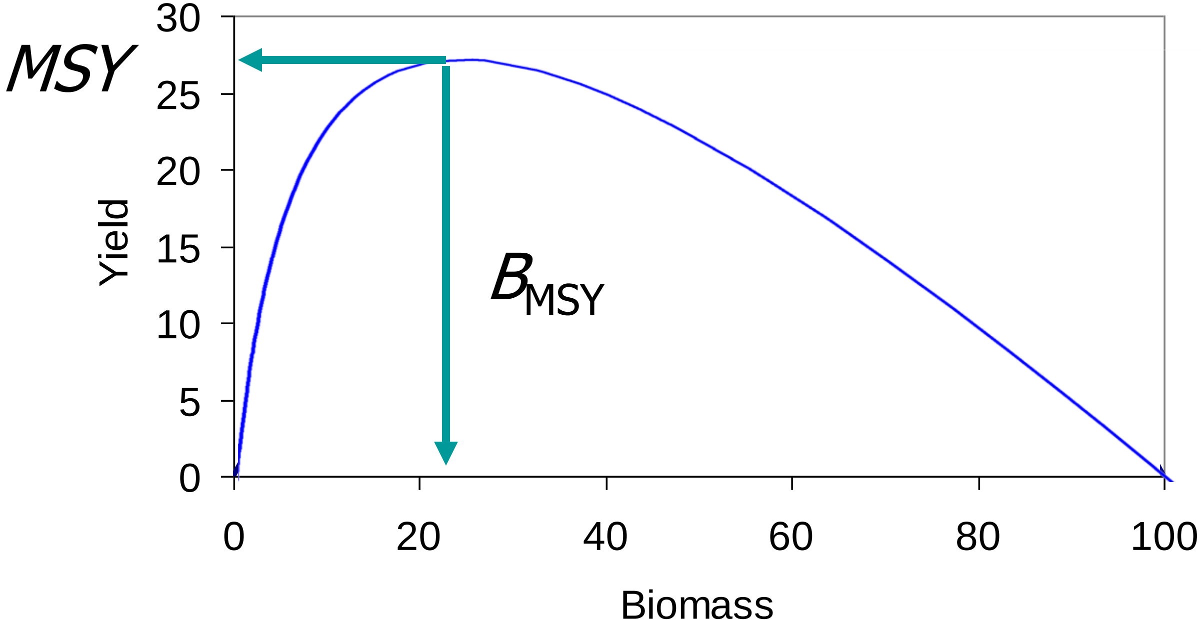
MSY Reference Points

- *B*MSY – the biomass at which Maximum Sustainable Yield, *MSY*, is achieved.
- Shape depends on model: e.g. Schaefer



MSY Reference Points

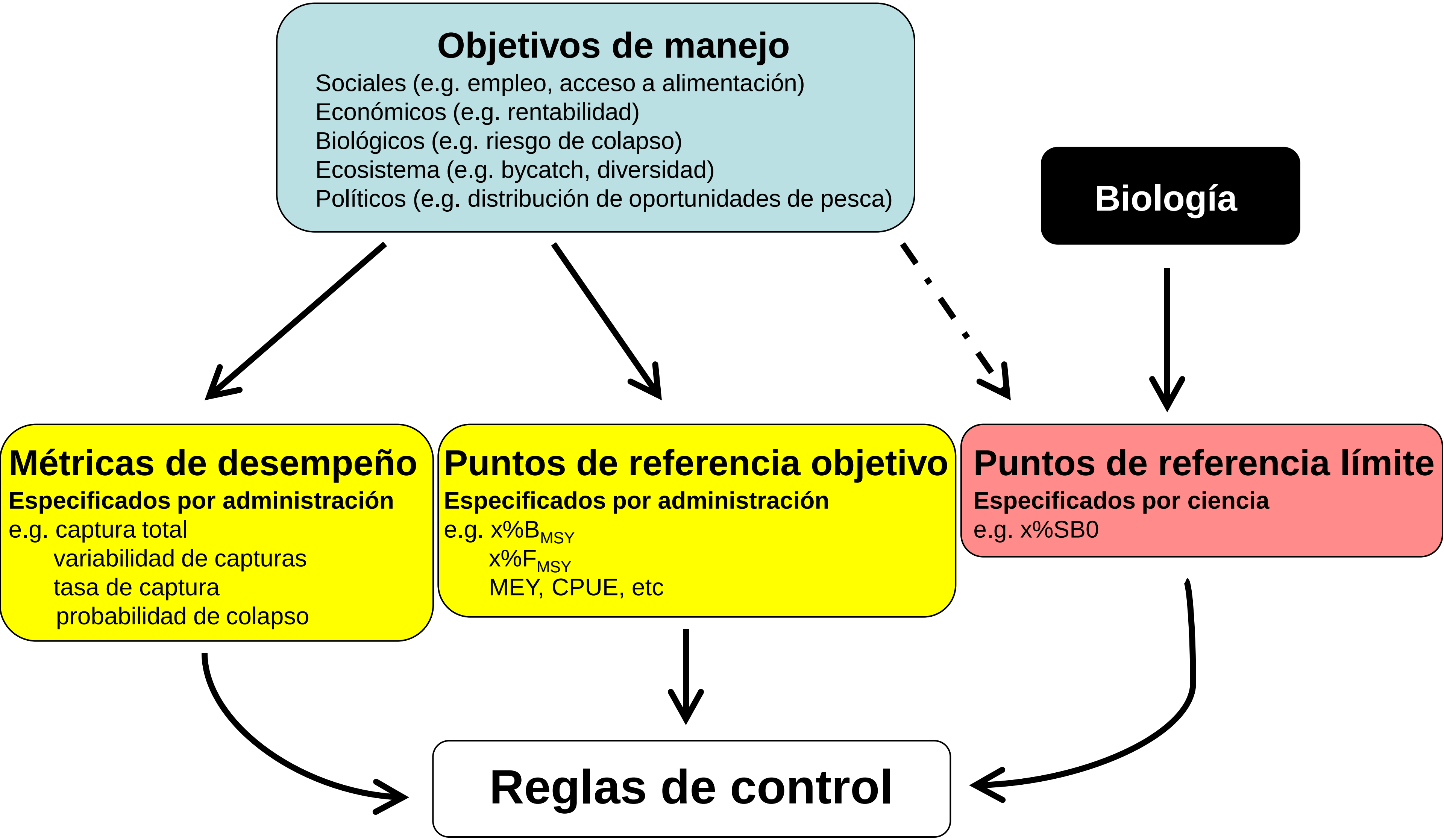
- B_{MSY} – the biomass at which Maximum Sustainable Yield, *MSY*, is achieved.
- Shape depends on model: e.g. Statistical C@A



Other Biomass Reference Levels

- 20% B_0 – when selecting policies consider the probability of dropping below 20% B_0 (a “level one does not go below”).
- An example: Accept no policy that has a greater than 10% probability of dropping below 20% B_0 over a 20-year projection period.
- Problems with approaches based on a fixed proportion of B_0: arbitrary, too cautious for some species, not cautious enough for other species.

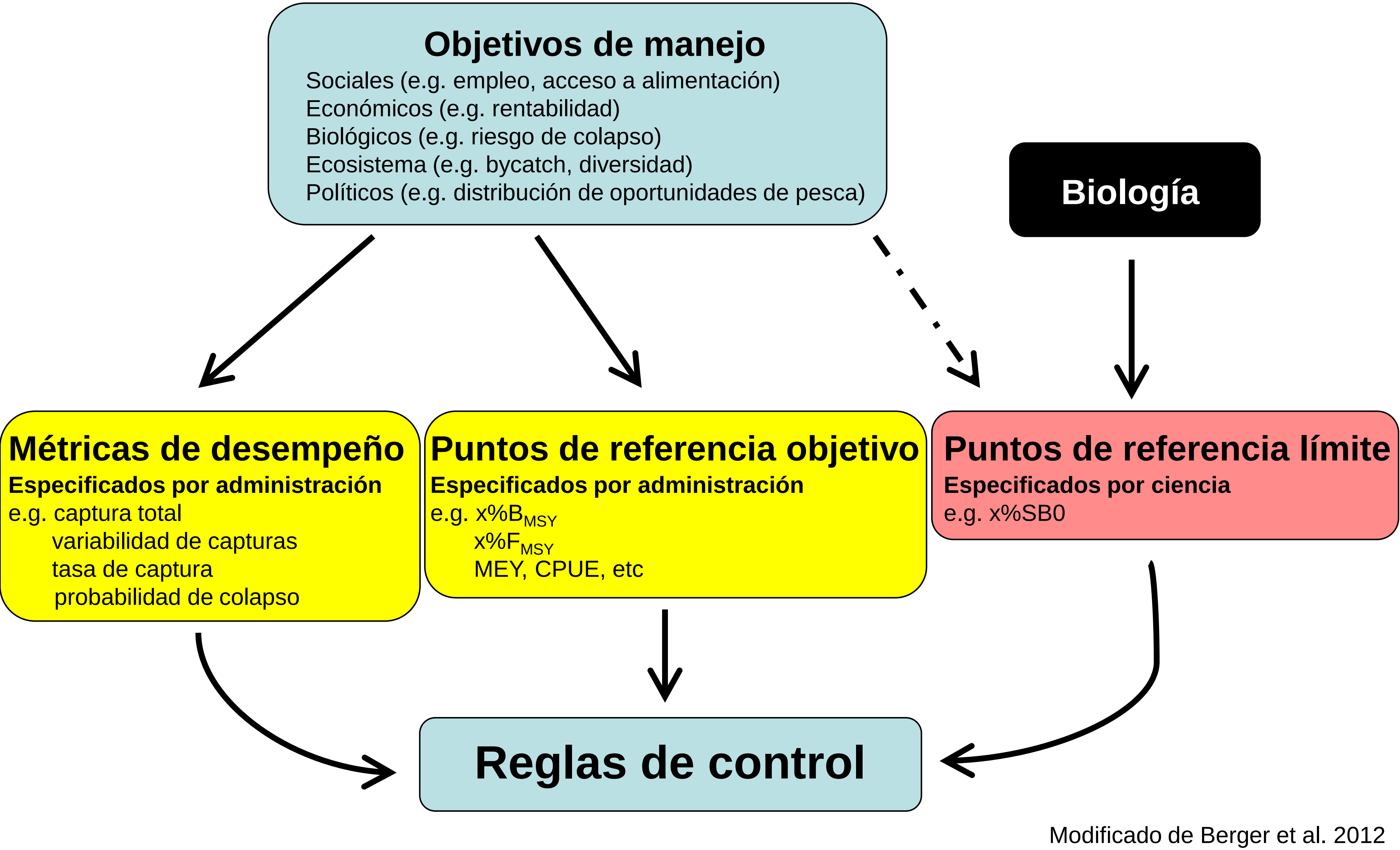
Cual es el rol de cada participante?



Modificado de Berger et al. 2012

Cual es el rol de cada participante?

- Managers and stakeholders identify management objectives, candidate target reference points, options for harvest control rules, and the criteria against which their performance should be evaluated.
- Scientists identify appropriate biological limits to exploitation and evaluate the performance of identified candidate harvest control rules.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Reglas de control
Modificado de Berger et al. 2012

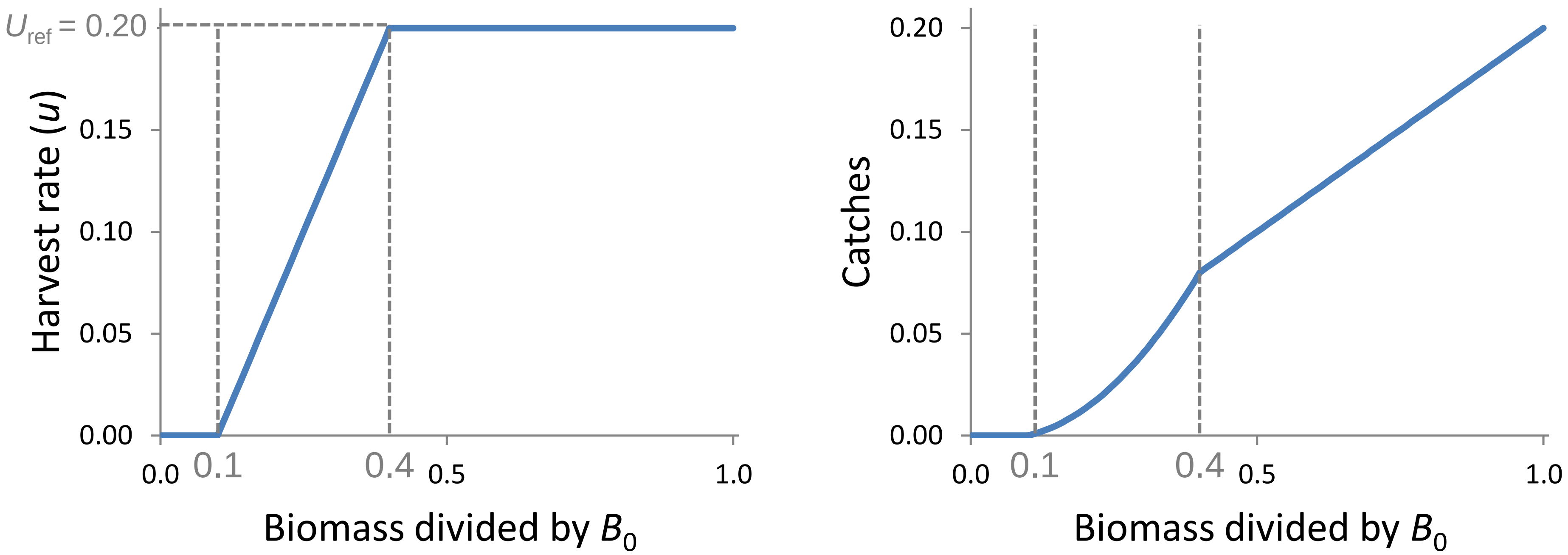
Reglas de Control

- Las reglas de control identifican reglas **pre-acordadas** de acciones de manejo en respuesta a cambios en el estado del recurso y/o otras condiciones económicas, ambientales en relación a **puntos de referencia** pre-establecidos.

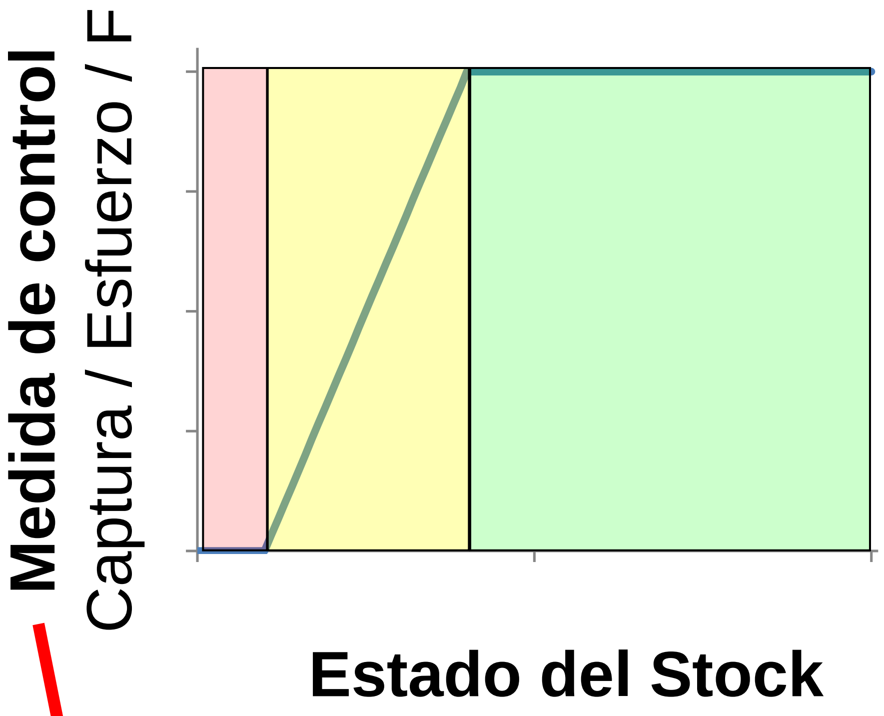
Reglas de Control

- Allow to operationalize **management objectives**
- Integrate management elements (**reference points**)
- Specify **pre-agreed management responses** to changes in the status of the stock
- Increase **transparency** in how harvest management decisions are made
- Provide a means for the development of rational fisheries management strategies through **science-based decision-making.**

Reglas de control: e.g. 40:10

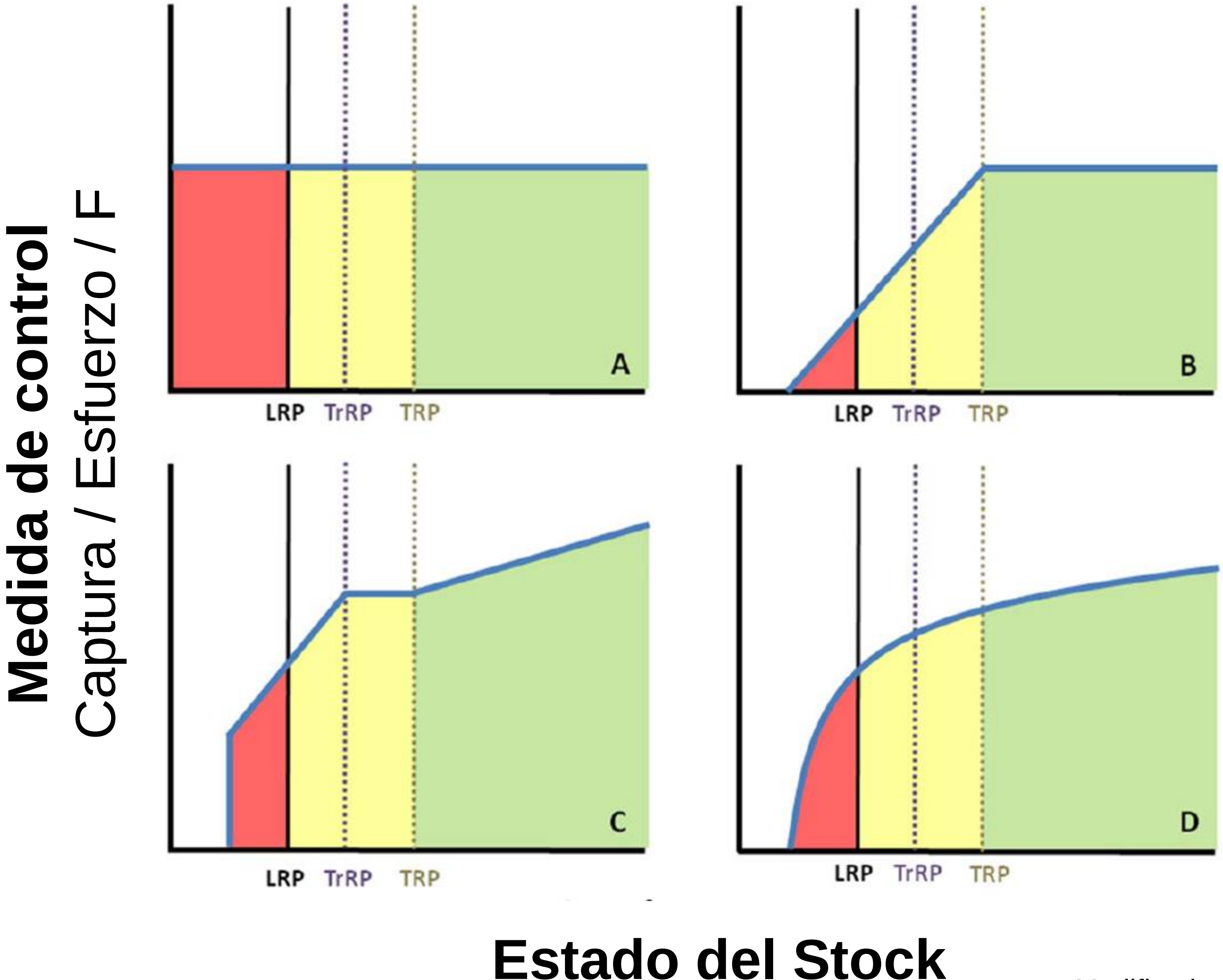


Elementos adicionales de las reglas de control



- **Medida/instrumento de control, tácticas:**
  - Son las regulaciones disponibles para la aplicación de la estrategia

Ejemplos de Reglas de Control



Modificado de Berger et al. 2012

Estrategias de explotación

- Combinación de monitoreo, **evaluación del estado del stock**, regla de control y acciones de manejo diseñadas para alcanzar los objetivos de la pesquería.
- Acciones de manejo incluyen el uso de por ejemplo: acceso limitado, distribución de derechos de pesca, **controles de entrada y salida**.
- El nivel de detalle y énfasis de estos componentes de la estrategia de explotación varia entre pesquerías y su contexto histórico (e.g. en desarrollo, estables, en recuperación) en particular el nivel de desarrollo de sistemas de monitoreo y manejo

Constant strategies

- Constant catch
- Constant harvest rate
- Constant escapement

Catch limit Regulation

- Many fisheries are managed by means of a simple decision rule
- Implementation issues:
  - Low catch limits may be unacceptable for socio-economic reasons.
  - (Very) high catch limits may be unacceptable due to lack of catching / processing capacity.
  - Large changes in catch limit are highly undesirable.
  - Discarding / high-grading will / may occur.

Catch limit Regulation

- Notes:
  - Is often worthwhile allowing for some random error between the catch limit and the landed catch.
  - The vulnerability for the landed catch will be less than that for the total catch for all ages if discarding occurs for reasons other than size (e.g. marketability).
  - Estimating the discard vulnerability function requires data on the discarded component of the catch (this is often not easy to get).

Otras estrategias de explotación

Periodic harvesting

- Also known as pulse harvesting
- Geoducks, clear-cut logging
- Good if large economies of scale
- Good if old individuals are particularly valuable and there is no possibility of size/age selective harvesting

Sex-specific harvesting

- Take the males, they are pretty useless
- Used primarily in fisheries where animals can be returned to the water with good chance of survival and sex can be determined
- Crabs, lobsters etc.
- Caution: Alaskan crab stocks crashed despite males only
- How to calculate needed sex ratio

Size limits

- Commonly used in invertebrate fisheries and sport fisheries
- Set minimum size limit above age at first reproduction

Failure to conserve stocks for sustainable use, why?

- Poorly defined management objectives
- Poorly defined conceptual basis for reference points
- Problems of estimating reference points and stock status
- Difficulty of scientists in communicating these problems to managers and stakeholders
- Failure of management to constrain fisheries to agreed levels

General trend in management towards more precautionary approach

- More aggressive : F_{max} and F_{msy}
- More conservative : $F_{0.1}$, $2/3F_{msy}$, $F_{40\%}$ and $F_{35\%}$
- Thresholds to protect stock against collapse F_{med}

Other alternative solutions

- Be much more cautious
- Be much more pro-active and be prepared for rapid changes in quota
- Accept much higher risk than we normally admit

Evaluación de estrategias

- It is often the objective for developing and fitting a model is to address “what if” questions. What is the impact of:
  - removal limits (quotas: individual / Olympic);
  - time / area closures;
  - gear restrictions (number of pots, traps, gillnets);
  - bag limits;
  - minimum / maximum sizes; and
  - vessel numbers / size of vessels.

Evaluación de estrategias

- We are often not looking for optimal strategies. Rather, we want to identify strategies that are robust to:
  - Estimation error.
  - Uncertainty regarding the true model.
  - Implementation uncertainty.
  - Environmental forcing and environmental change.
- “Optimal policies” can often be found if we know the true model but these may perform poorly if applied to the wrong model.

Evaluación de estrategias
Objetivos y tácticas

- Estrategias are based on choosing tactics (quotas, minimum sizes, closed areas) to achieve management objectives / goals.
- Corollary - if we don't know the management objectives we cannot (sensibly) compare different policies.
- Problem: often the decision makers have not agreed on any objectives (or are unwilling to state their objectives publicly).

Evaluación de estrategias

Objetivos y tácticas

- We distinguish between high-level objectives (e.g. conserve the stock) and operational (quantitative) objectives (the probability of dropping below $0.1B_0$ should not be greater than 0.1 over a 20-year period).

- Many decision makers confuse the tactics (what to do next year) with the objectives (why are we doing what we are doing next year).

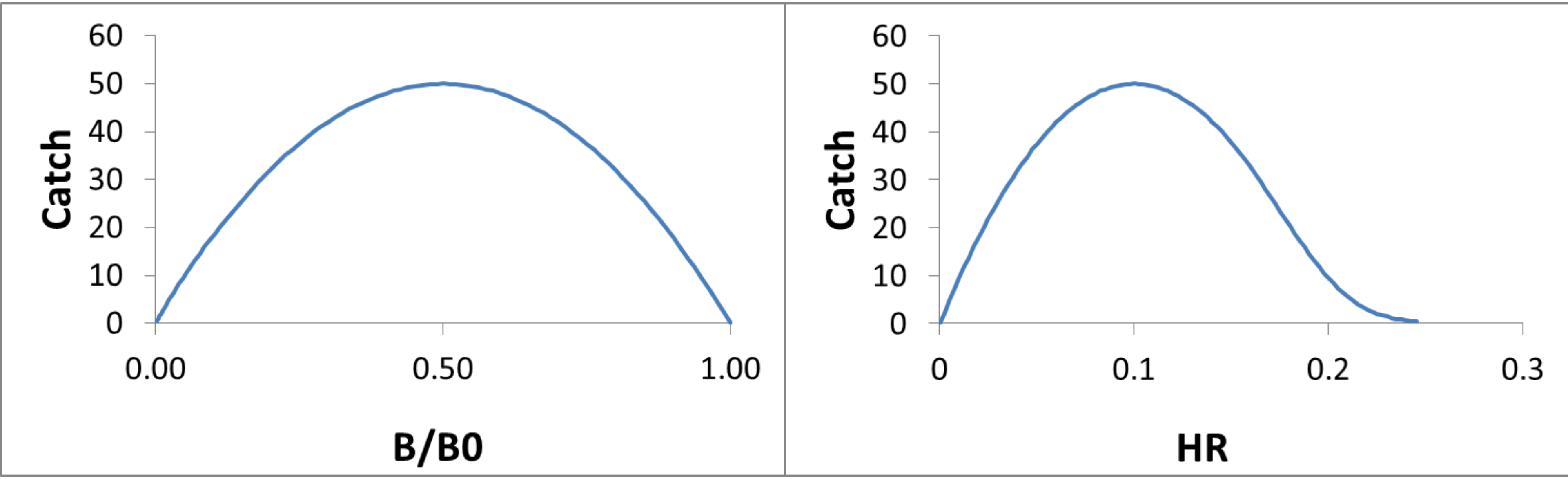
Técnicas para evaluar estrategias

- We can sometimes evaluate the implications of a policy analytically (e.g. the impact of changes in fishing intensity on yield-per-recruit).
- More commonly, we have to evaluate policy alternatives using Monte Carlo simulation methods.
  - Specify the high-level management objectives.
  - Specify the operational management objectives.
  - Develop models of the system to be managed (including their uncertainty).
  - Use simulation to determine the implications of each strategy.
  - Summarize the results.

Evaluando estrategias

- Model of the state of the system (Schaefer model):

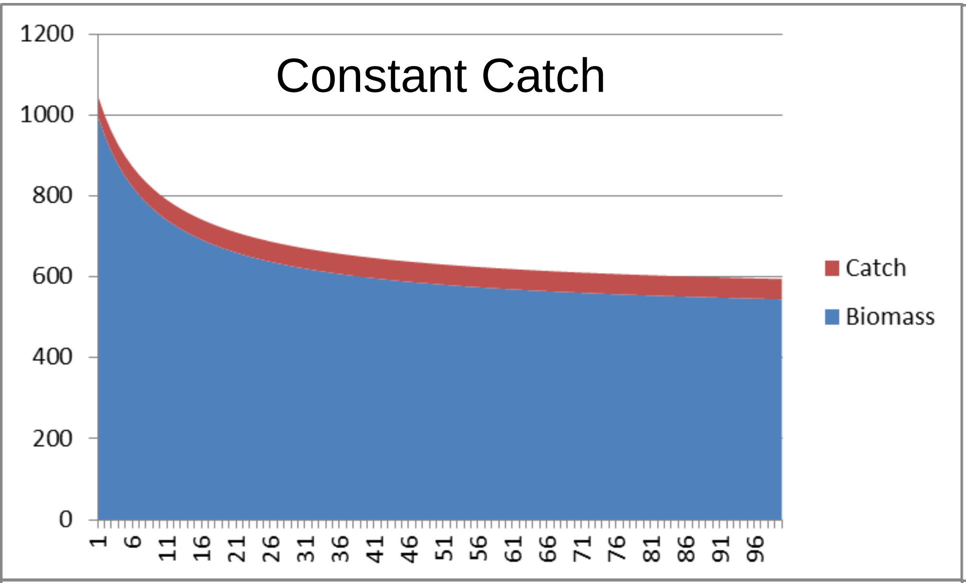
$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - C_t$$

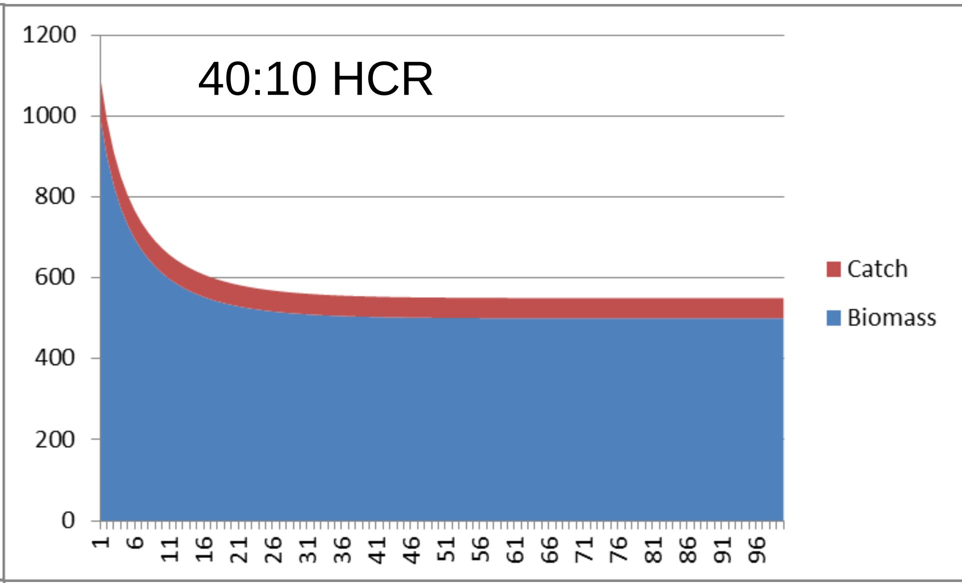


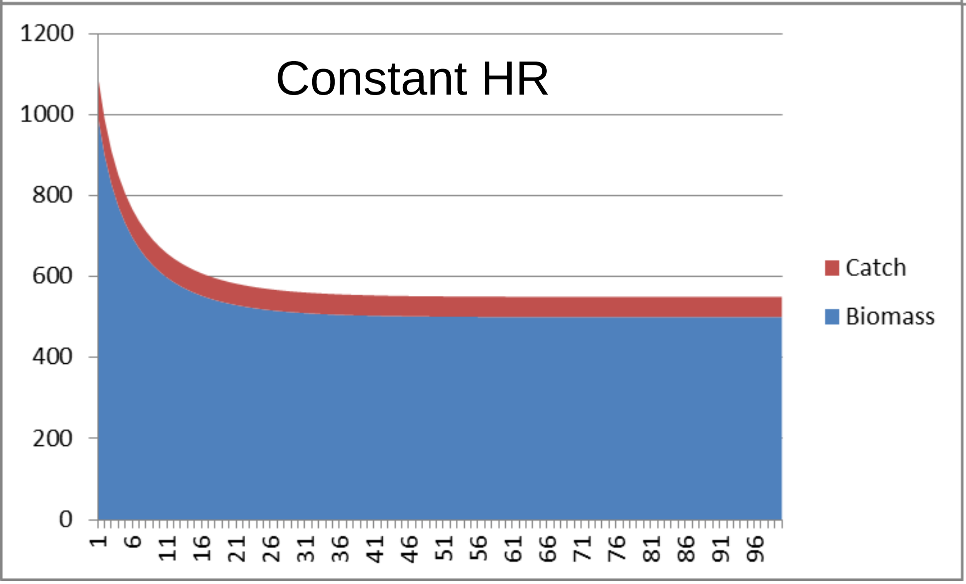
- This a deterministic model so we only have to do a single simulation as there is no uncertainty.

Ver Schaefer_Kobe.xlsx

Catch and Population Size Trajectories







Ver Schaefer_Kobe.xlsx

Extending to a Stochastic Model

- Model of the state of the system (Schaefer model):

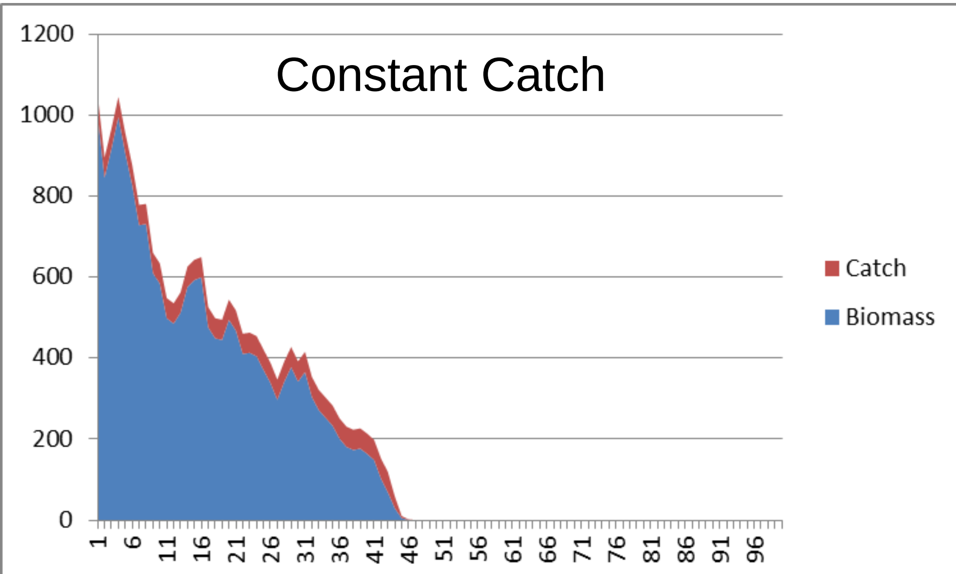
$$B_{t+1} = [B_t + r\,B_t(1 - B_t / K) - C_t]e^{\varepsilon_t - \sigma_p^2/2}; \qquad \varepsilon_t \sim N(0;\sigma_p^2)$$

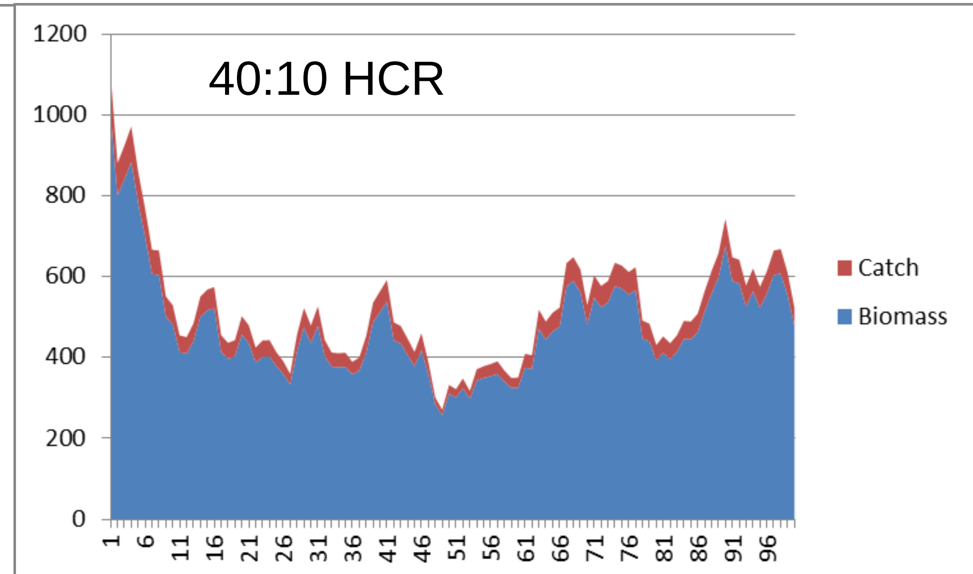
$$C_t = HCR \bullet B_t$$

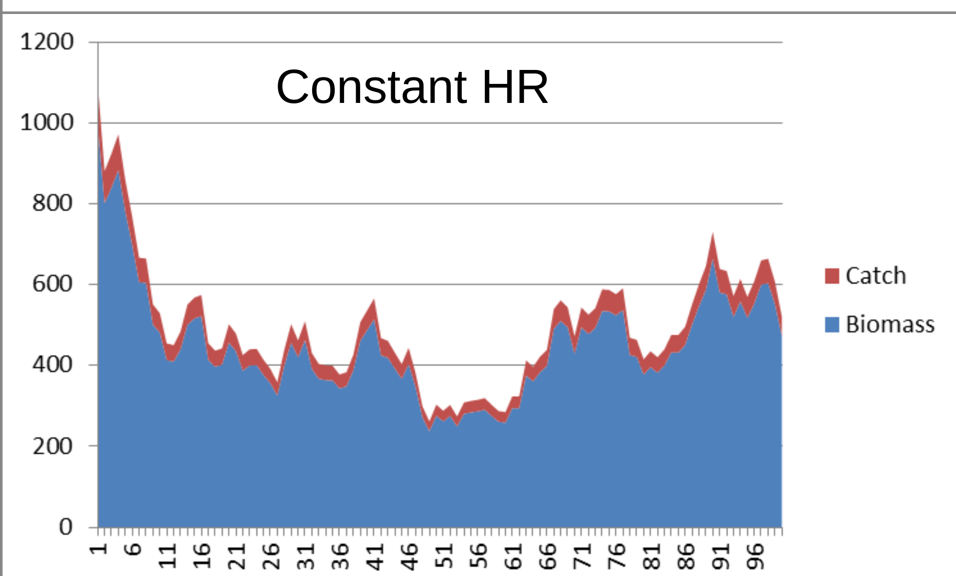
- This is now a stochastic model so we do 100 simulations (σ_p=0.1).

Ver Schaefer_Kobe.xlsx

Catch and Population Size Trajectories







Ver Schaefer_Kobe.xlsx

Allowing for Errors in Stock Assessment

- We now allow for correlated errors when conducting assessments (if this year's assessment is wrong, next year's is also likely to be wrong) :

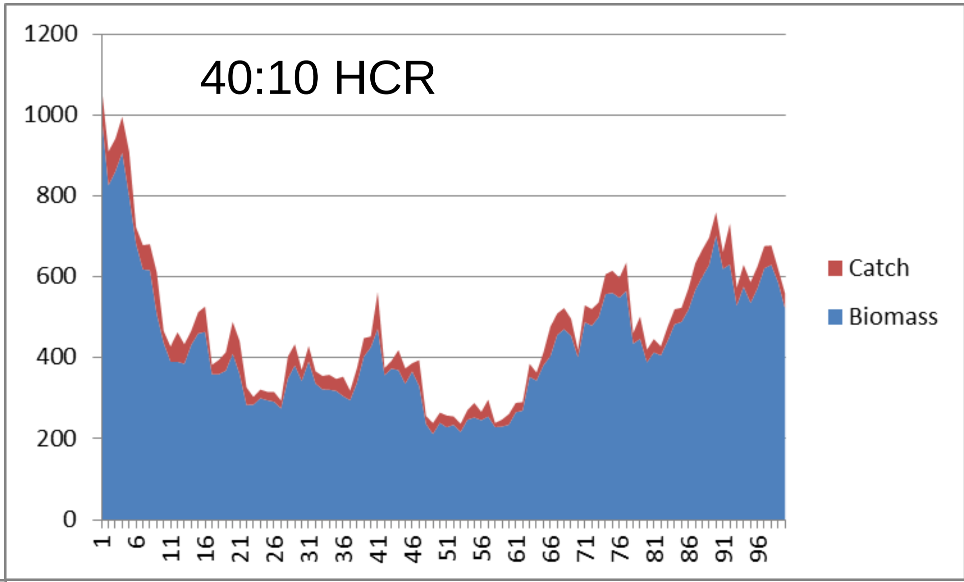
$$B_{t+1} = [B_t + r\,B_t(1 - B_t / K) - C_t]e^{\varepsilon_t - \sigma_p^2/2}; \qquad \varepsilon_t \sim N(0;\sigma_p^2)$$

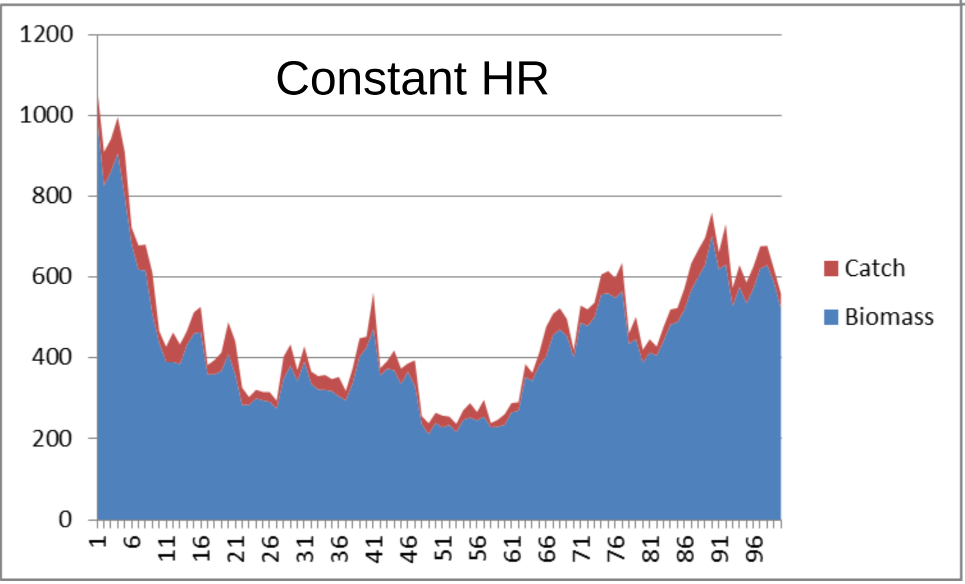
$$C_t = HCR \bullet B_t e^{\varepsilon_t - \sigma_e^2}; \qquad \varepsilon_t \sim N(0;\sigma_e^2)$$

- This approach to modeling assessment errors ignores biases in assessment results – also assessment errors are unlikely to be normally distributed.

Ver Schaefer_Kobe.xlsx

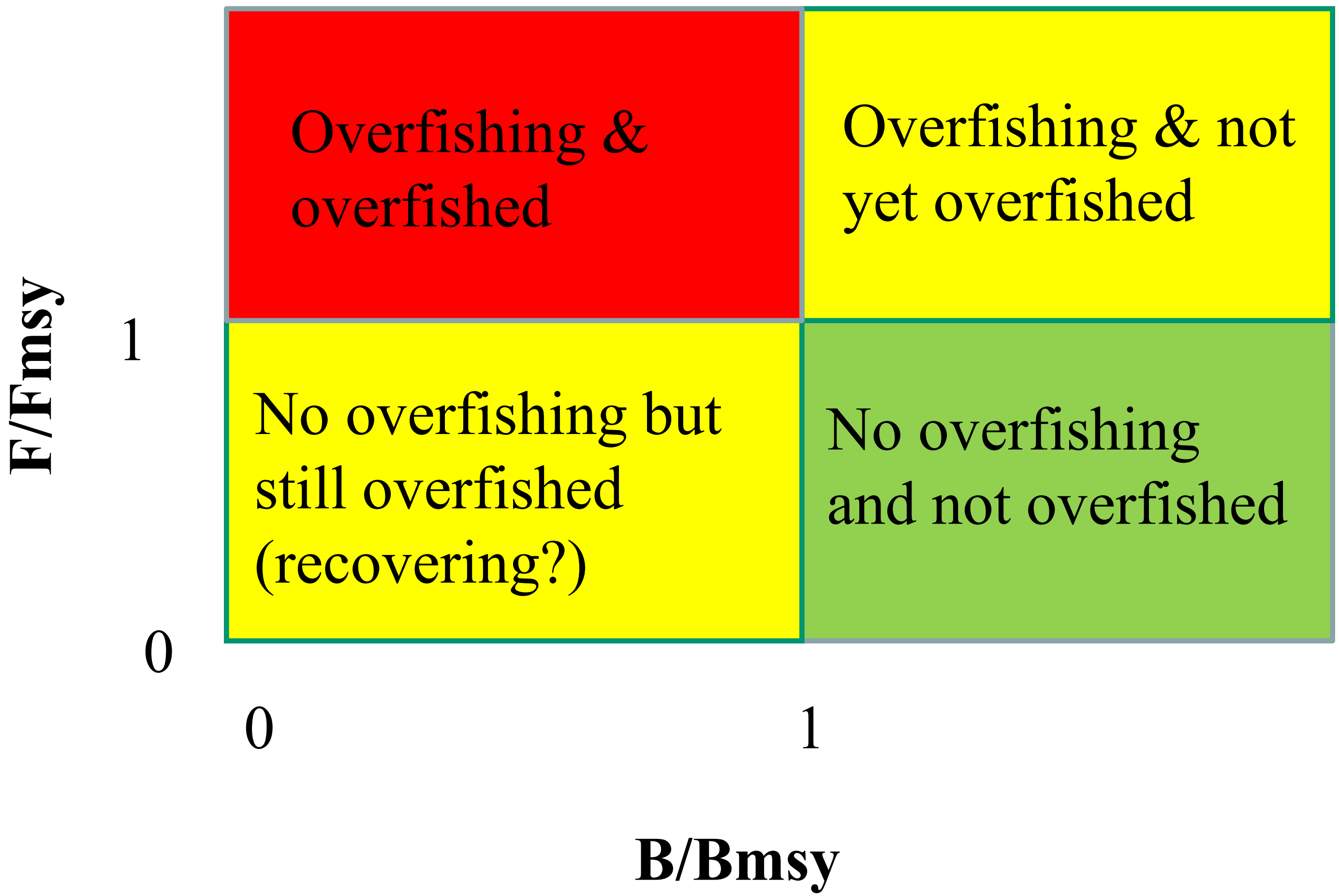
Catch and Population Size Trajectories





Ver Schaefer_Kobe.xlsx

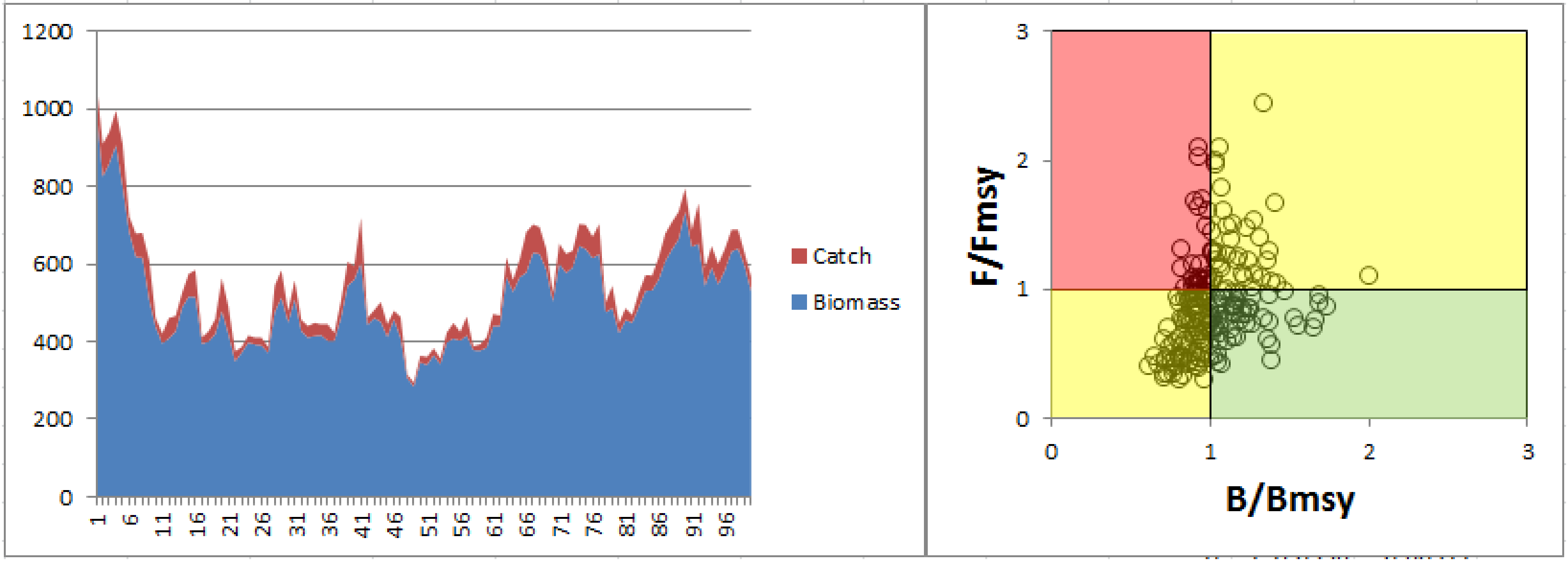
Kobe plot



Overfishing & overfished
Overfishing & not yet overfished
No overfishing but still overfished (recovering?)
No overfishing and not overfished
F/Fmsy
1
0
0
1
B/Bmsy

Kobe plot, simple Schaefer model

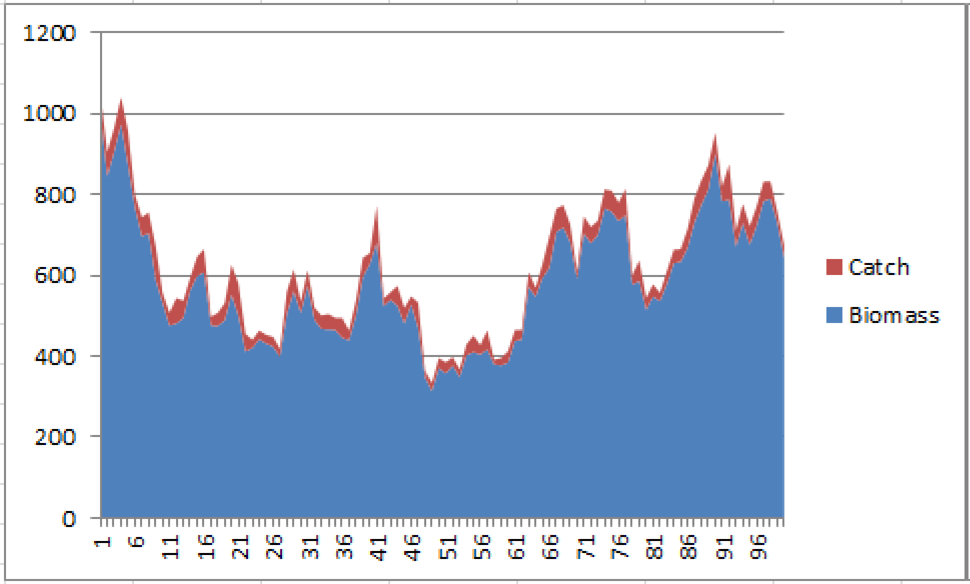
50:20 HCR, HR target (Fmsy) with Stock Assessment error

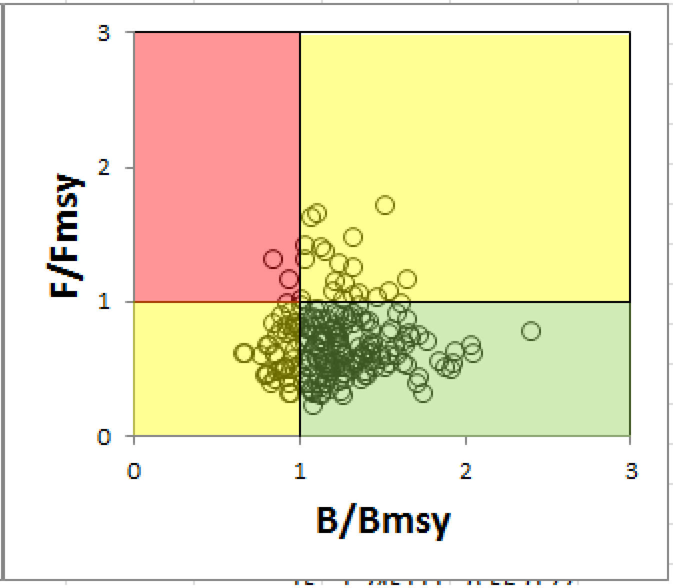


Ver Schaefer_Kobe.xlsx

Kobe plot, simple Schaefer model

40:10 HCR, HR target (0.7*Fmsy) with Stock Assessment error



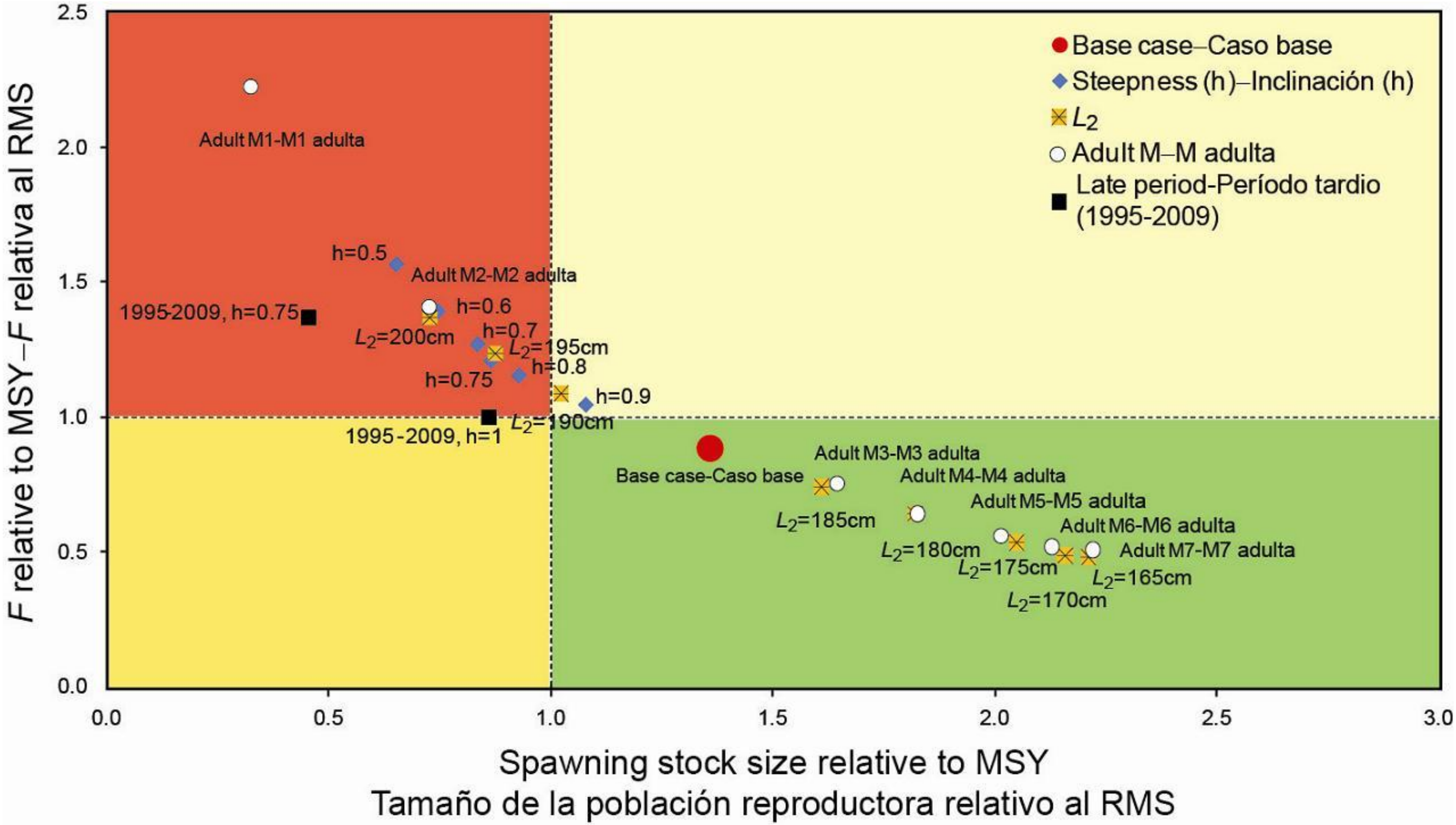


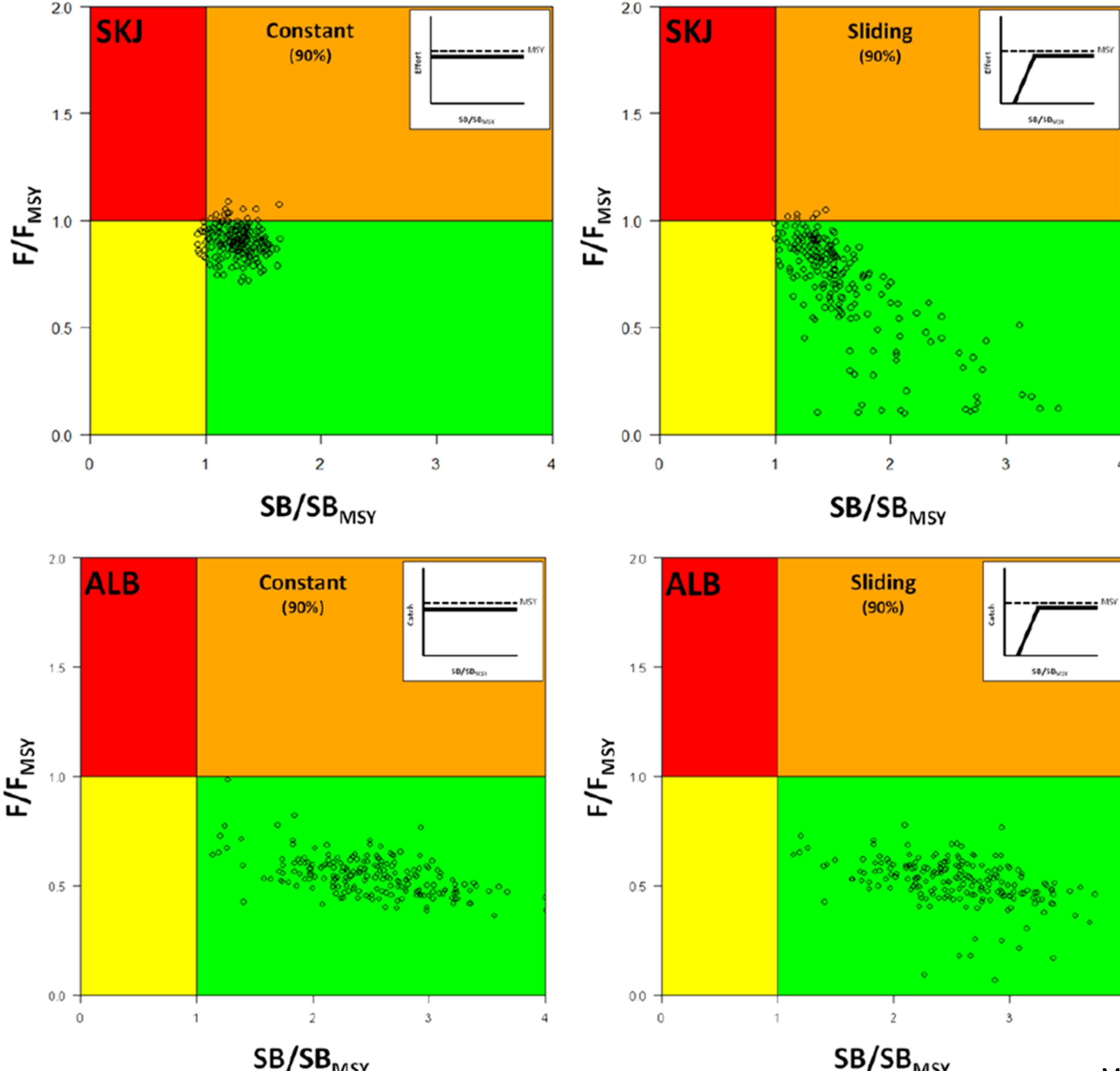
Ver Schaefer_Kobe.xlsx

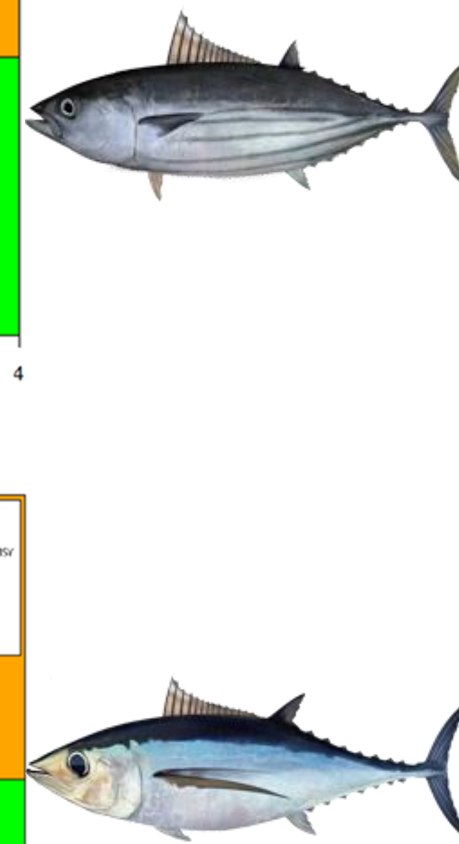
Going Beyond the Simple Case

- Rather than assume assessment errors are log-normally distributed, simulate the process of conducting annual assessments (this is highly computationally intensive).
- Examine strategies designed to achieve specific management objectives (e.g. select catch limits so that the probability of recovery equals a desired level).

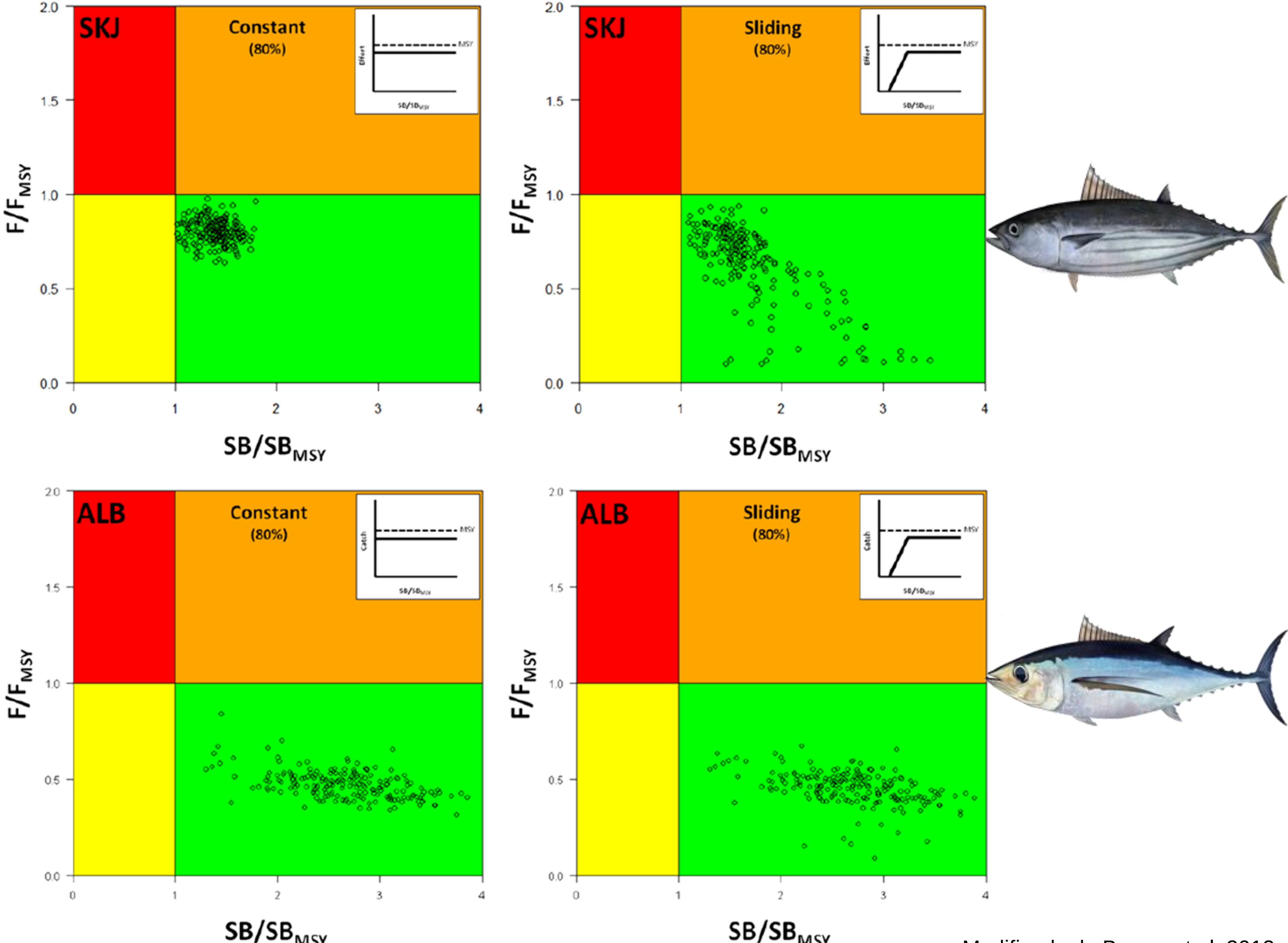
EPO Big Eye Tuna
Kobe plot with sensitivities







Modificado de Berger et al. 2012



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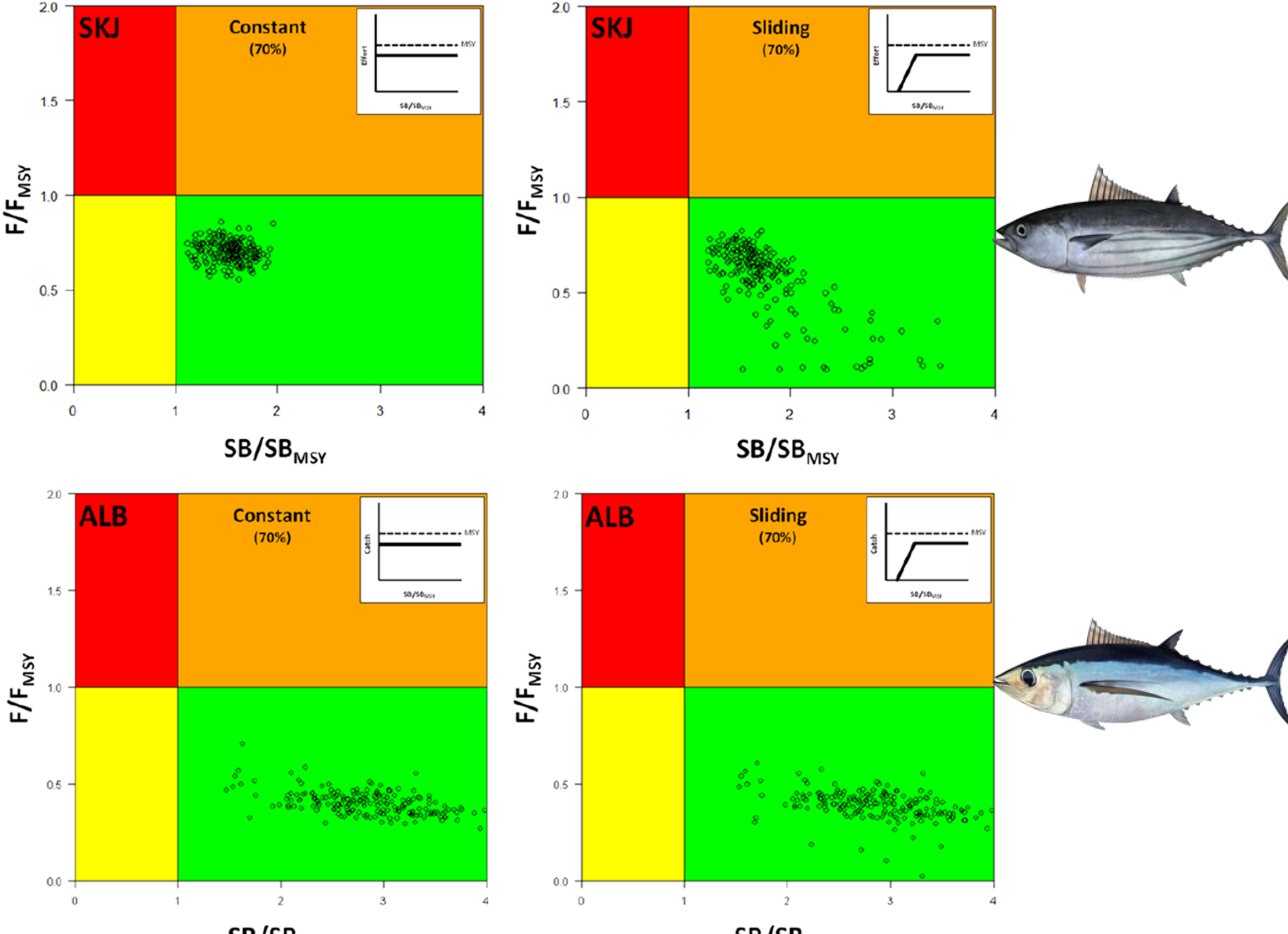


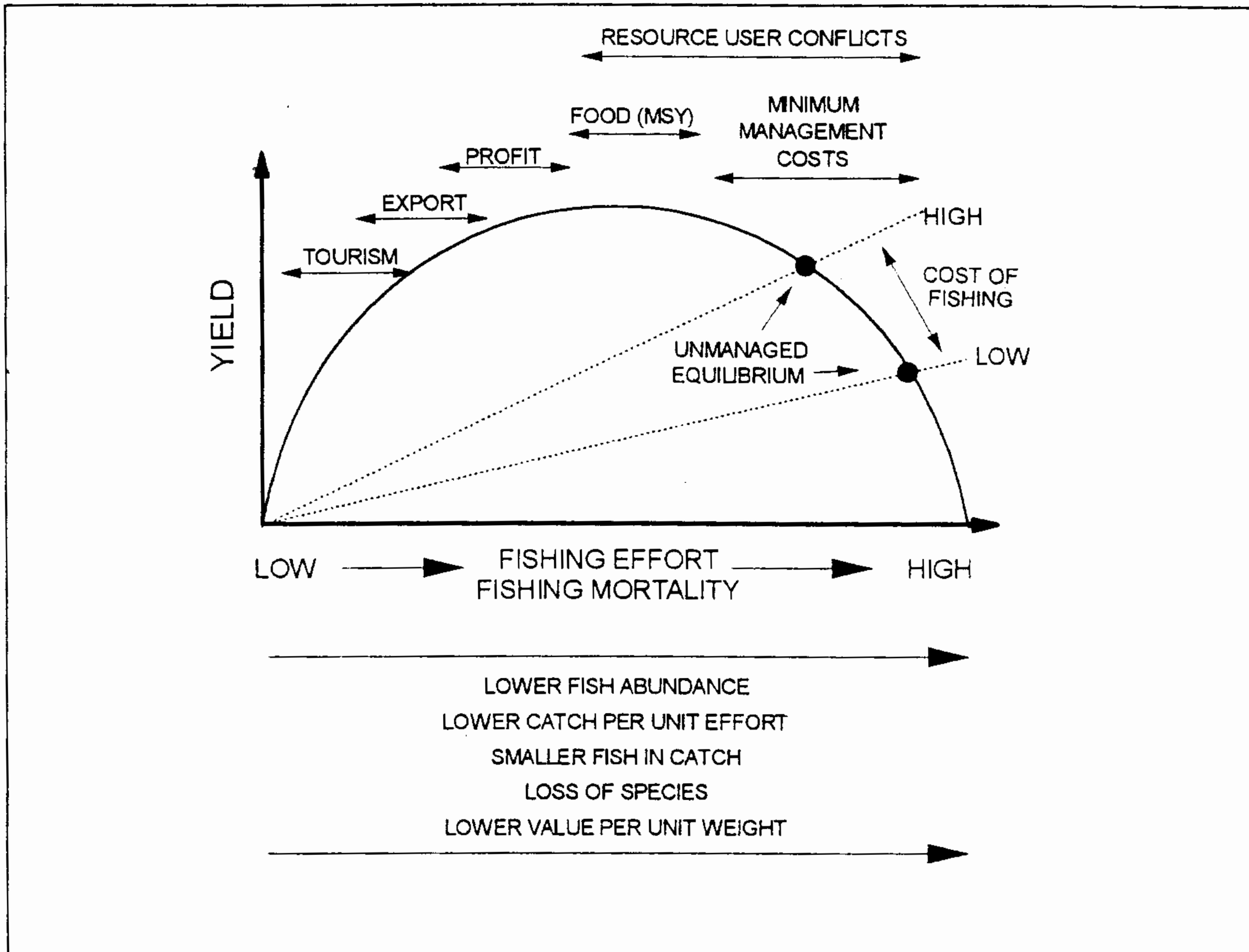
Modificado de Berger et al. 2012

Implementation Uncertainty

- Implementation uncertainty - how what happens in reality relates to the intended management action.
- It can be a very major effect (e.g. when catch limits are ignored if they are small).
- We now consider a range of typical policy types and how implementation uncertainty can be modeled for each.

General Policy Guidelines-I

- Keep the biomass *above* B_{MSY}:
  - Less risky to the target species.
  - Less impact on the ecosystem (although this is often not clear / provable).
  - Greater economic yields are likely given that catch rates will be higher.
  - Note that moving to B_{MSY} may lead to substantial short-term (negative) consequences. These need to be considered along with the benefits of being at or above B_{MSY}. For this reason, yield-per-recruit type analyses may be questionable.


RESOURCE USER CONFLICTS
FOOD (MSY)
MINIMUM MANAGEMENT COSTS
PROFIT
EXPORT
TOURISM
HIGH
COST OF FISHING
LOW
UNMANAGED EQUILIBRIUM
YIELD
LOW
FISHING EFFORT
FISHING MORTALITY
HIGH
LOWER FISH ABUNDANCE
LOWER CATCH PER UNIT EFFORT
SMALLER FISH IN CATCH
LOSS OF SPECIES
LOWER VALUE PER UNIT WEIGHT

General Policy Guidelines-II

- Employ spatial management to spread the catch spatially. Avoid the problems due to unknown stock structuring:
  - northern cod;
  - Icelandic fin whales.
- Spatial structuring of a harvesting operation may prevent catch rates providing information about changes in stock size because the harvesters will try to move to keep catch rates high even if stock size is declining.

Current Controversies-I

- No-take zones:
  - These have clear biodiversity / ecosystem benefits (more species, higher densities of target species, larger individual sizes).
  - It is not clear that no-take zones will, however, lead to increased yields, except when the fishery is essentially unmanaged.
  - These depend on the success of enforcement (many small zones versus few large ones).

Current Controversies-II

- Ecosystem management:
  - What does it mean?
    - Tropic interactions, ecosystem functioning, reducing bycatch (of megafauna).
  - Can it be based on models? – are the current generation of ecosystem models too complicated with too many parameters to make reliable predictions?
  - What performance measures should we use to evaluate specific policies (e.g. how to evaluate species of no commercial value)?