FISHERIES MANAGEMENT - DOES SELECTIVITY MATTER?

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OUTLINE

I INTRODUCTION

II ASSESSMENT AND REFERENCE POINTS

a) EARLIER AGES

Gulf of Maine cod

b) OLDER AGES

Gulf of Maine cod, New England white hake, winter flounder and pollock, Atlantic menhaden

III MANAGEMENT PROCEDURES (MSE)

SA and Tristan lobster, PEI Toothfish, SBT, Canadian pollock, SA hake, Greenland halibut

IV SUMMARY IMPRESSIONS

I. INTRODUCTION

Whale Assessments and TAC recommendations in the early 1980s

Age-aggregated models fitted to CPUE

Bill de la Mare – mid-1980s

"Hitter-Fitter" package (deterministic ASPM)

Inputs included *M*, selectivity ogive, etc.

"I produced the package to show that selections for these parameters don't matter"

Does this generalise?

Note:

For whales data are typically historic catches, one or a few absolute abundances from surveys, and a relative abundance time series.

A productivity parameter (like Schaefer r is either estimated or fixed on input.)

II. ASSESSMENTS AND REFERENCE POINTS - EARLIER AGES

Gulf of Maine cod

Surveys from 1962, but catches aged only from 1982

Survey catch-at-age from 1970

Survey catch-at-length from 1962

Assessments and BRPs

Previously VPA

Necessarily starts from 1982; proxies used for MSY BRPs

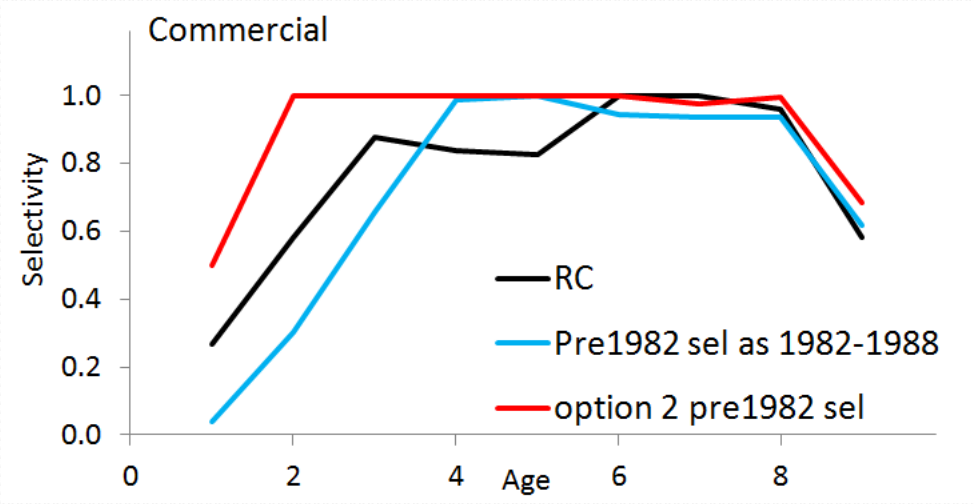
More recently move to SCAA(SCAL)

Can start from 1962; more contrast to estimate S/R relation, hence estimate BRPs directly

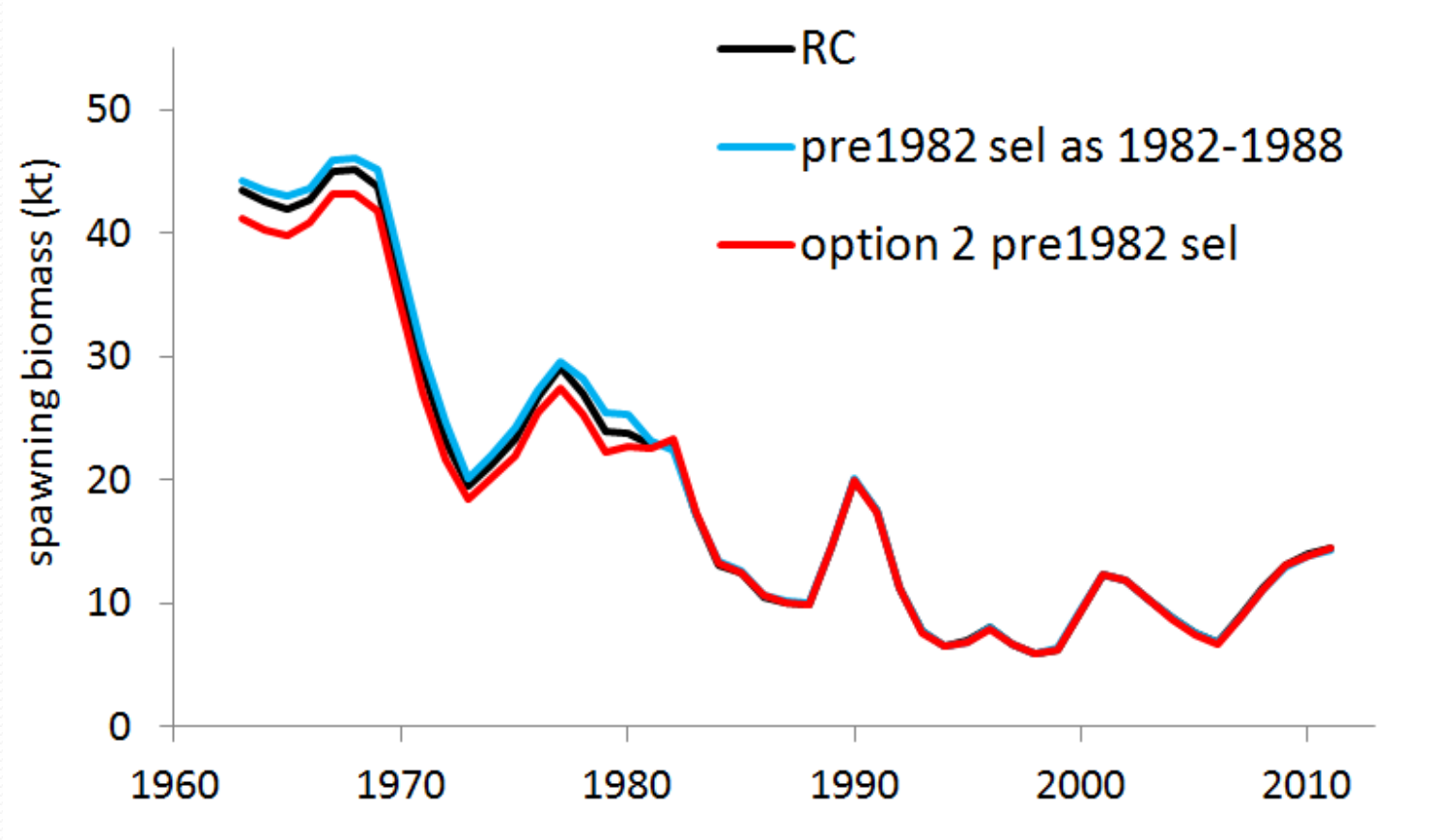
BUT pre-1982 start questioned given absence of CAA/CAL data from that period to inform on commercial selectivity

EARLY AGE SELECTIVITY

- Does it matter much?
- Gulf of Maine cod – No commercial CAA data pre-1982
- Alternative pre-1982 selectivity assumptions



Gulf of Maine cod SCAA assessment sensitivities



SELECTIVITY SENSITIVITY – EARLY AGES

Minimal (at least in this case)

Why?

Shepherd production curve model

Production ~ Recruitment only, as Somatic growth gain roughly cancels Natural Mortality loss

i.e. Cohort biomass typically doesn't change too fast with age

Implication

Changing assumptions about the ages at which past catches were taken has only a small impact

II. ASSESSMENTS AND REFERENCE POINTS - OLDER AGES

VPA assessments

Typically asymptotically flat selectivity assumed (Fy,m = Fy,m-1) - in 1980s and 1990s, focus was on tuning algorithms for current F's.

? Because VPA was first developed for stocks in the eastern North Atlantic under heavy F's so few old fish left ?

Gulf of Maine cod (2008)

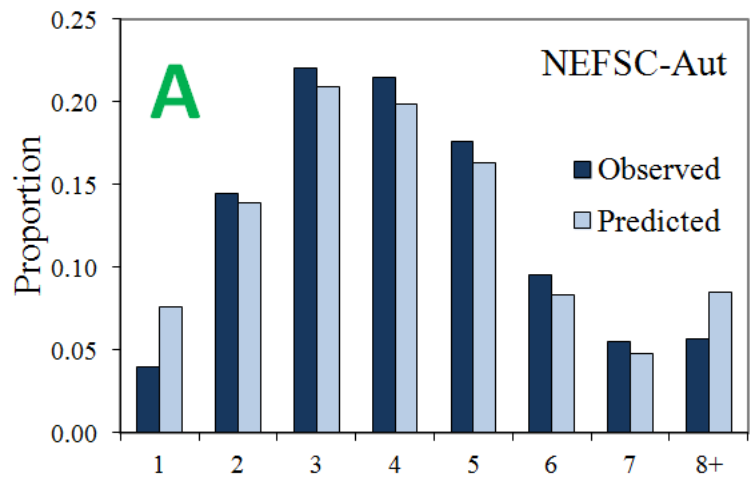
[Note data including catch-at-age estimates subsequently refined]

With the introduction of SCAA, alternatives came under consideration.

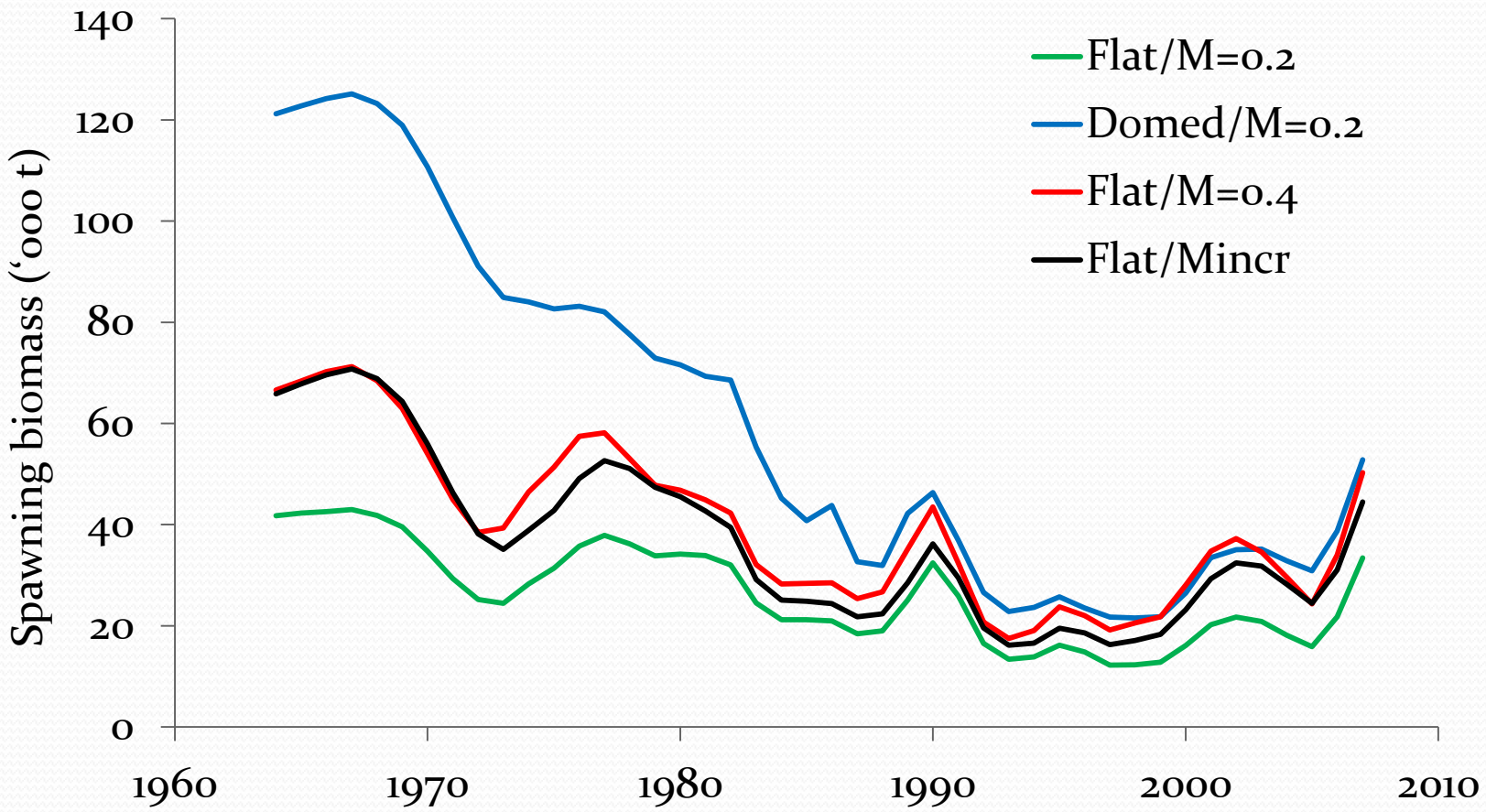
Plus group catch paucity - alternatives

	A	B	C	D
Survey selectivity	flat	domed	flat	flat
M	0.2	0.2	0.4	0.2 incr

M incr is at an estimated exponential rate above age 4



Spawning biomass series estimates



Biological Reference Points

	A	B	C	D
Survey selectivity	flat	domed	flat	flat
M	0.2	0.2	0.4	0.2 incr
Δ-lnL	38.6	0.0	4.1	4.3
K^{sp}	63.5	129.9	70.1	69.3
B^{sp}_{2007}	33.4	52.8	50.3	44.5
B^{sp}_{MSY}	24.8	51.0	30.0	31.5
$B^{sp}_{2007}/B^{sp}_{MSY}$	1.35	1.04	1.68	1.41
MSY	12.7	13.4	13.5	13.5
F_{MSY}	0.49	0.37	0.56	0.43
F_{2007}	0.23	0.20	0.19	0.18
$F_{40\%}$	0.14	0.21	0.38	0.33

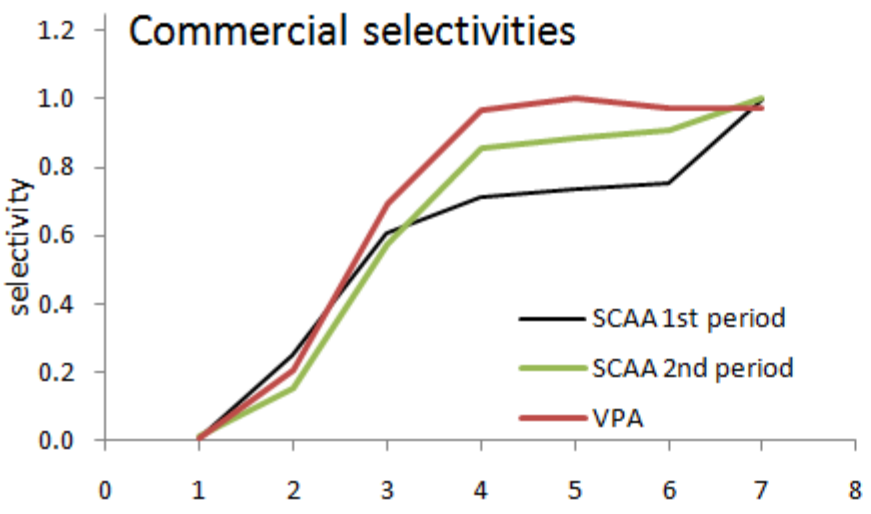
GULF OR MAINE COD – In Summary

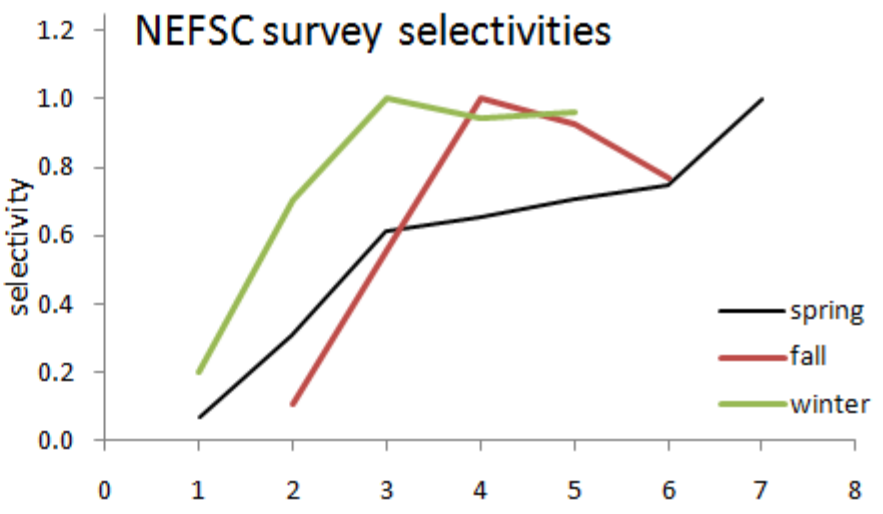
- **Alternatives have higher biomasses**
  - Particularly with domed selectivity
  - Particularly historically
- **MSY robustly determined** (12.7 to 13.5 '000 mt)
- **Overfished status not robustly determined**
  - Bcurr/Bmsy: 1.04 to 1.68
- **Overfishing status not robustly determined**
  - Fcurr/Fmsy: 0.34 to 0.54 (direct)
  - 0.50 to 1.64 (F40% proxy)

OTHER NEW ENGLAND GROUNDFISH ASSESSMENTS

- Winter Flounder
- White hake
- Pollock

Winter flounder selectivities

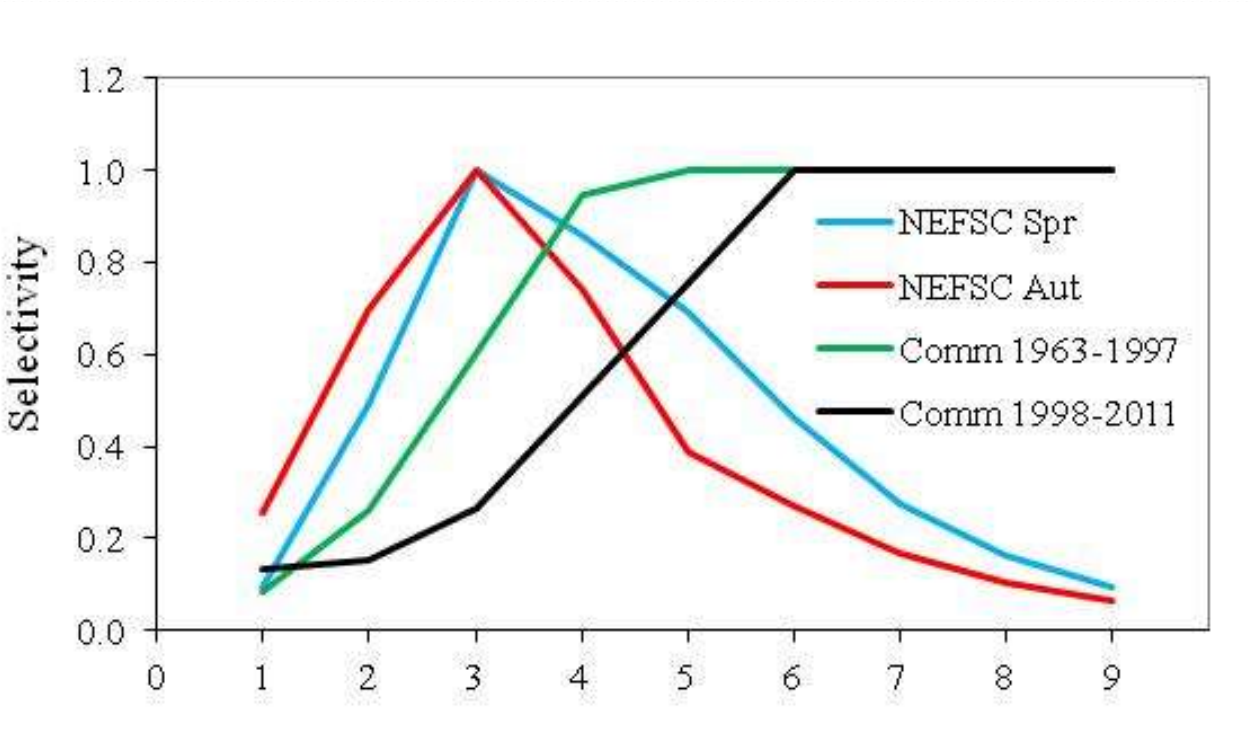




S's freely estimated.

Focus was on retrospective pattern, including possible recent increase in *M*.

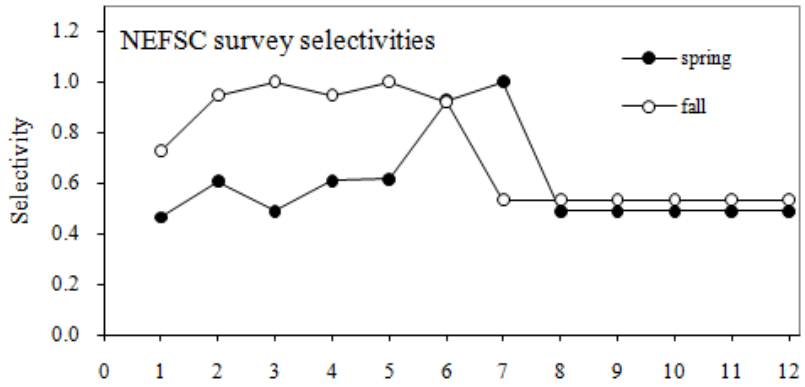
White hake selectivities

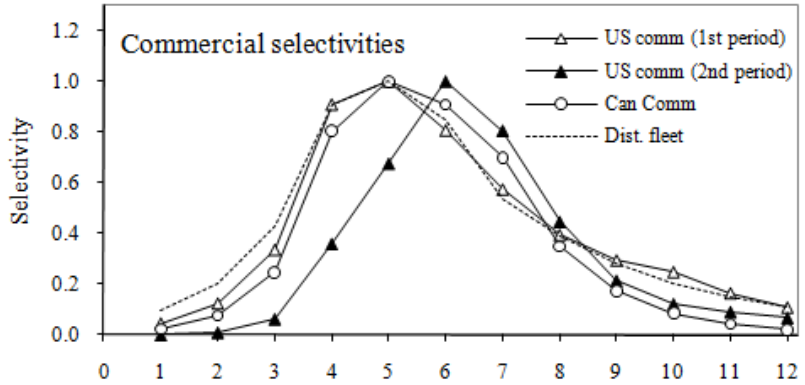


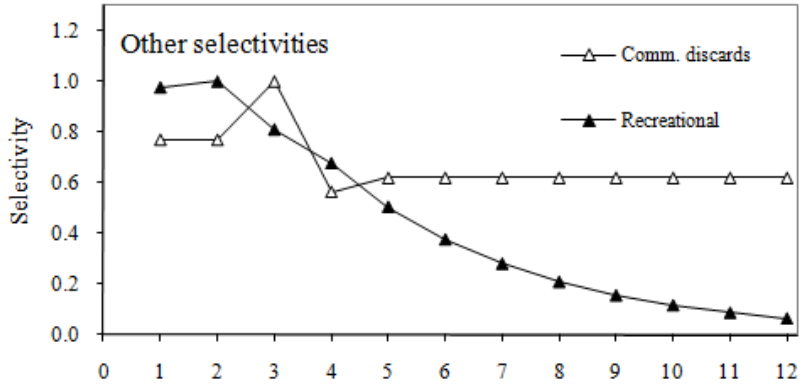
-lnL prefers flat commercial S (for M=0.2).

-lnL also insists on domed survey S's.

Pollock selectivities







-lnL favoured survey selectivity dome (for M=0.2).

Without dome, yield estimates about 30% lower

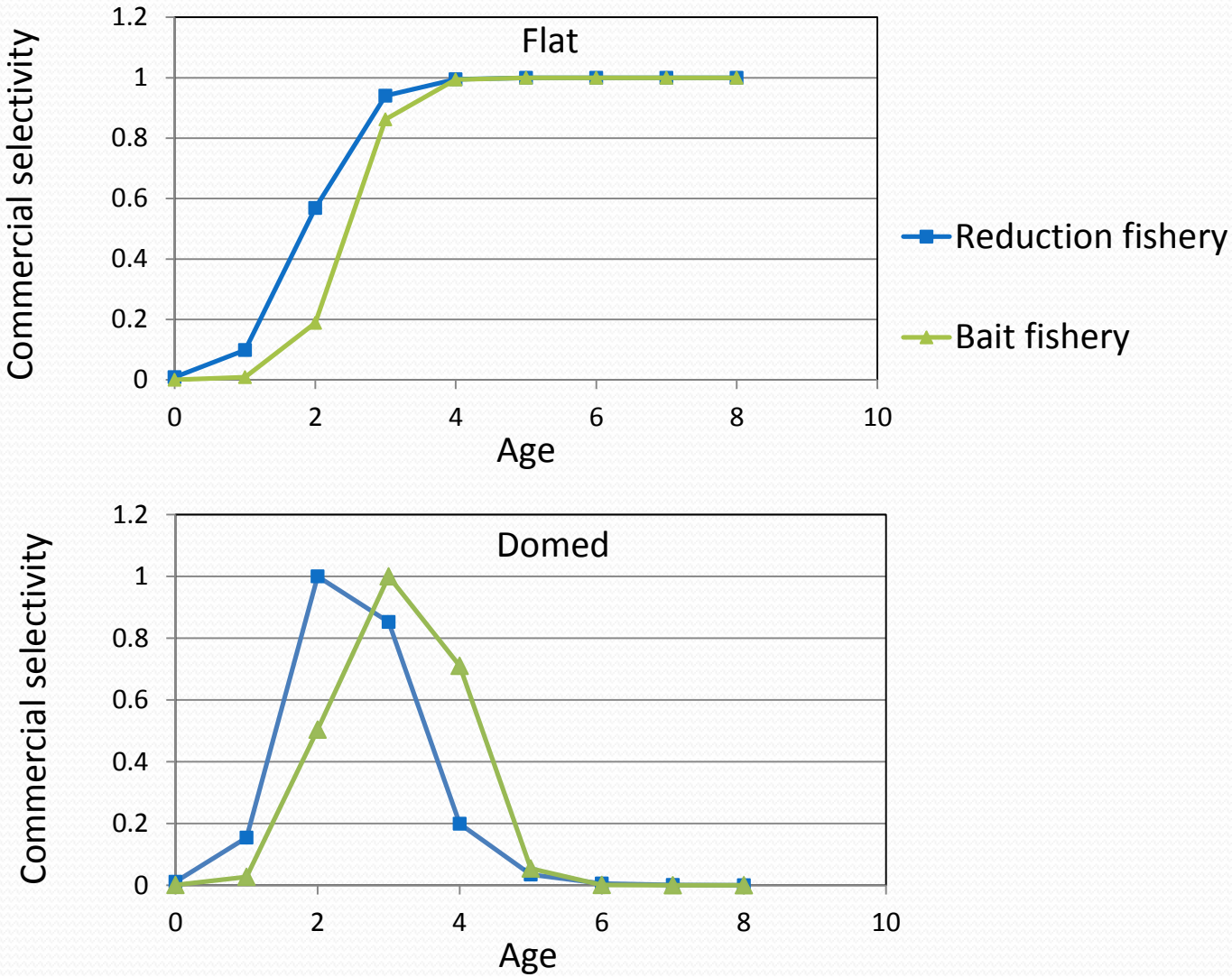
OTHER NEW ENGLAND GROUNDFISH ASSESSMENTS – In Summary

- There is frequently statistical support for selectivity doming for either or both the survey and the commercial catch selectivities (given the *M* value assumed).
- This sometimes has important implications for BRPs and associated management advice.

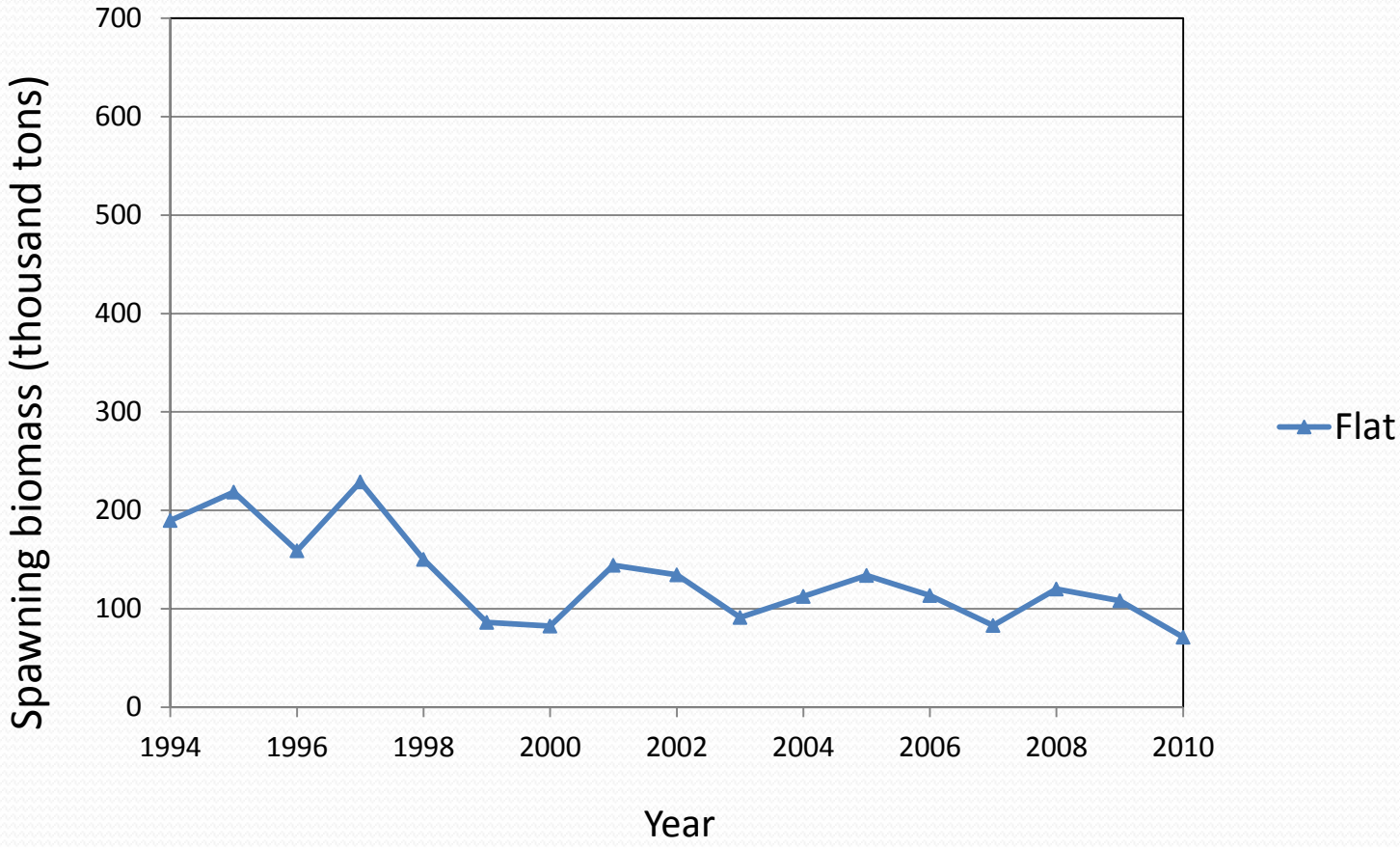
ATLANTIC MENHADEN

- Second largest US fishery by volume (including Gulf menhaden)
- Now mainly restricted to Chesapeake Bay and nearshore Virginia waters
- Menhaden also occur further north, with a tendency to be older
- Relatively poor resource abundance indices – recruitment index extracted from surveys targeted at other species plus CPUE from one river fishery
- Two fisheries – reduction and bait. The currently accepted baseline assessment assumes both to have asymptotically flat selectivities.

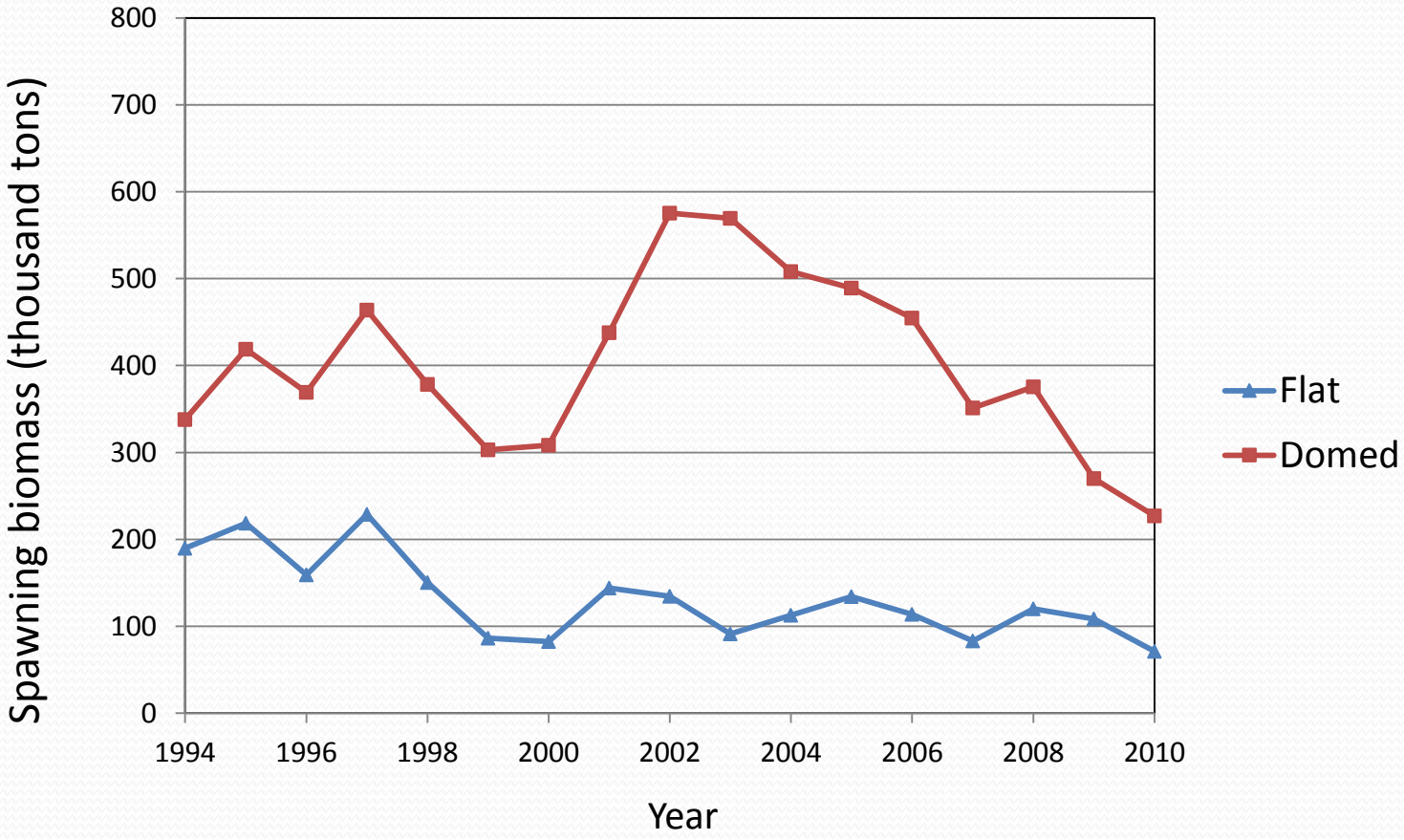
SELECTIVITIES AT AGE



MENHADEN ASSESSMENTS

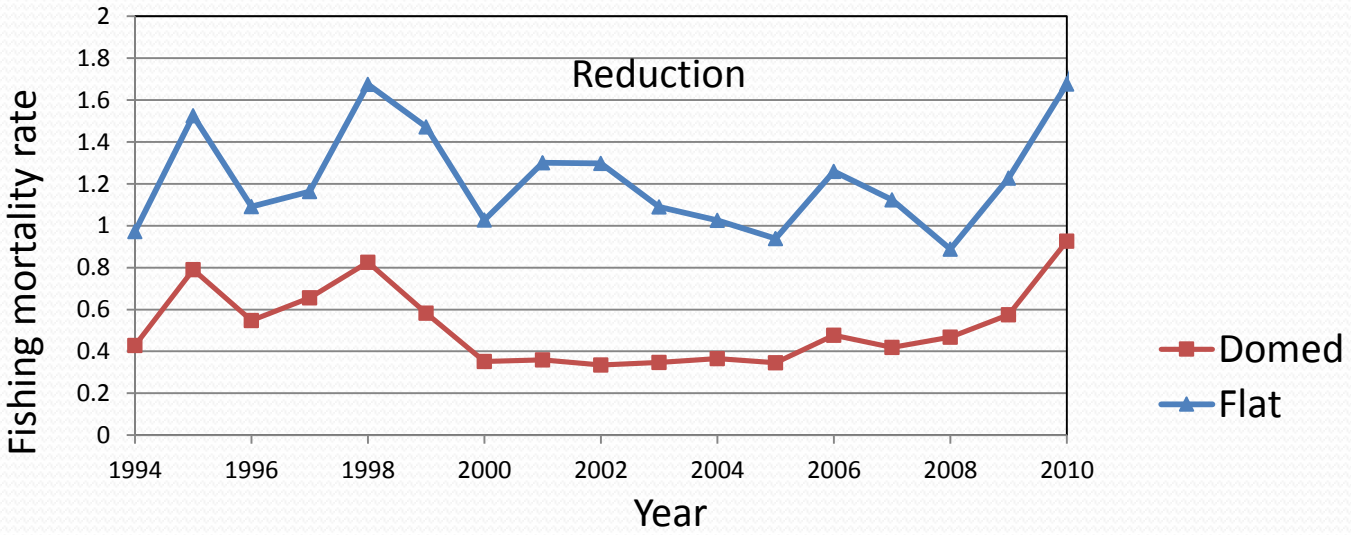


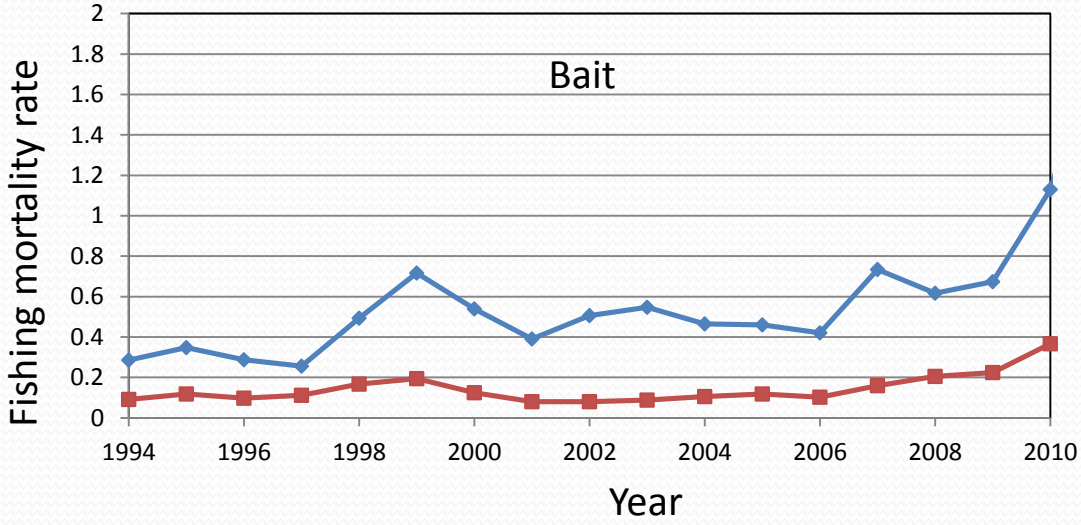
MENHADEN ASSESSMENTS



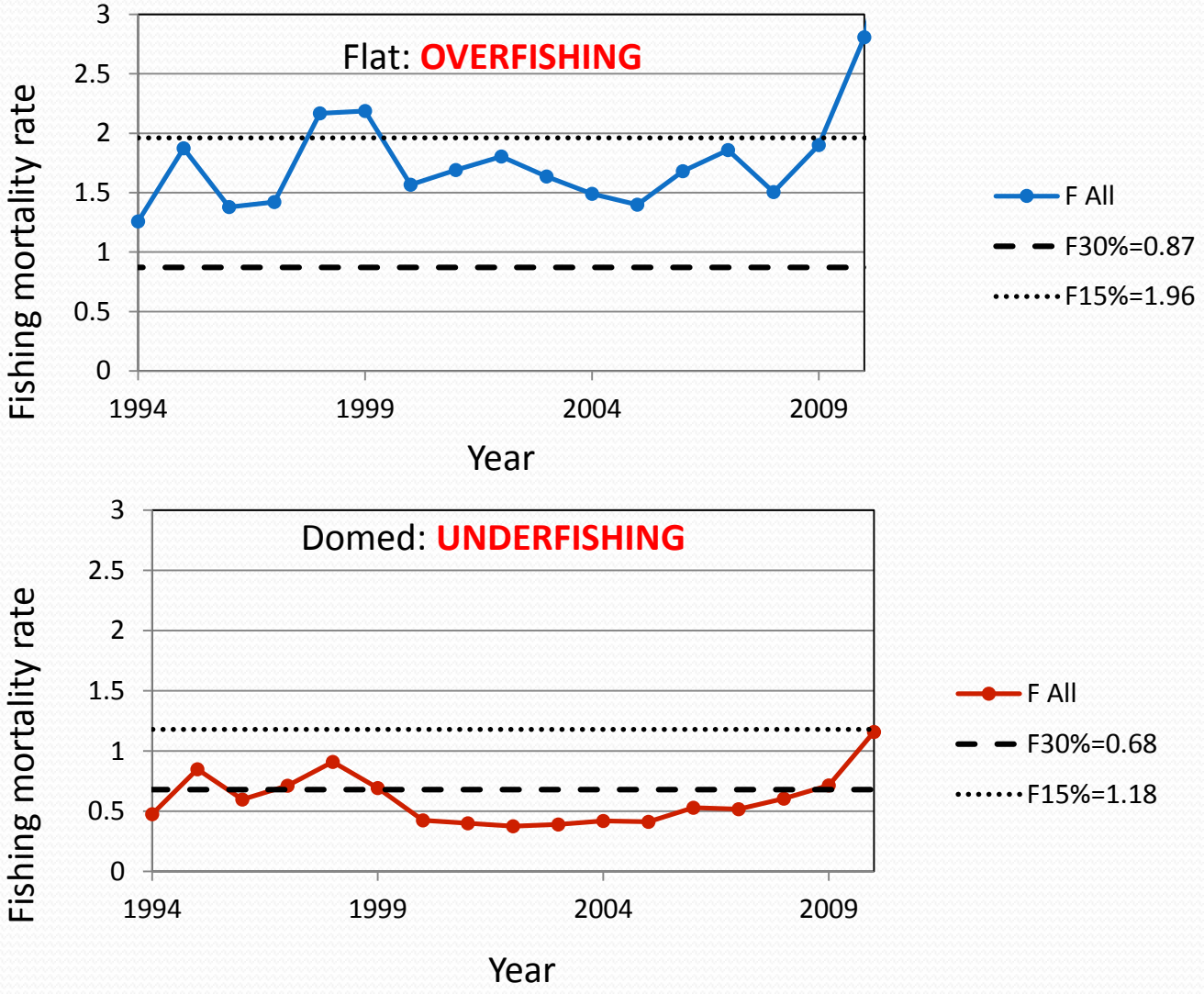
-LnL improves by 35 for 8 estimable parameters

MENHADEN FISHING MORTALITIES





TOTAL F REFERENCE POINTS



Use aerial surveys to independently determine dome extent

ATLANTIC MENHADEN– In Summary

- Emigration of older fish north of the fishing area is a plausible mechanism for doming
- Domed selectivity possibility has major implications for BRPs and overfishing status evaluation

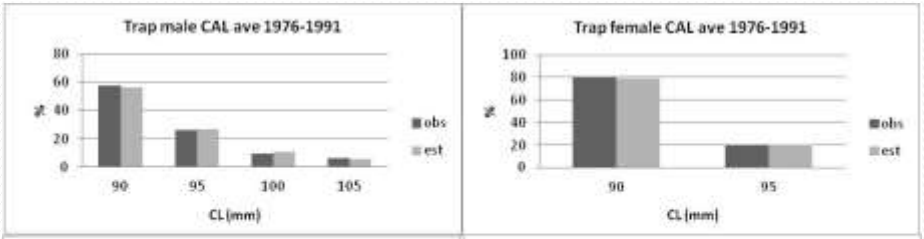
III. MANAGEMENT PROCEDURES (MSE)

VARIOUS LOBSTER FISHERIES

- SA West Coast rock lobster (five areas) – shallow water – length based assessment – empirical MP
- SA South Coast rock lobster (three areas) – deep water – SCAL – empirical MP
- Tristan lobster (four islands) – shallow water – SCAL – MP under development

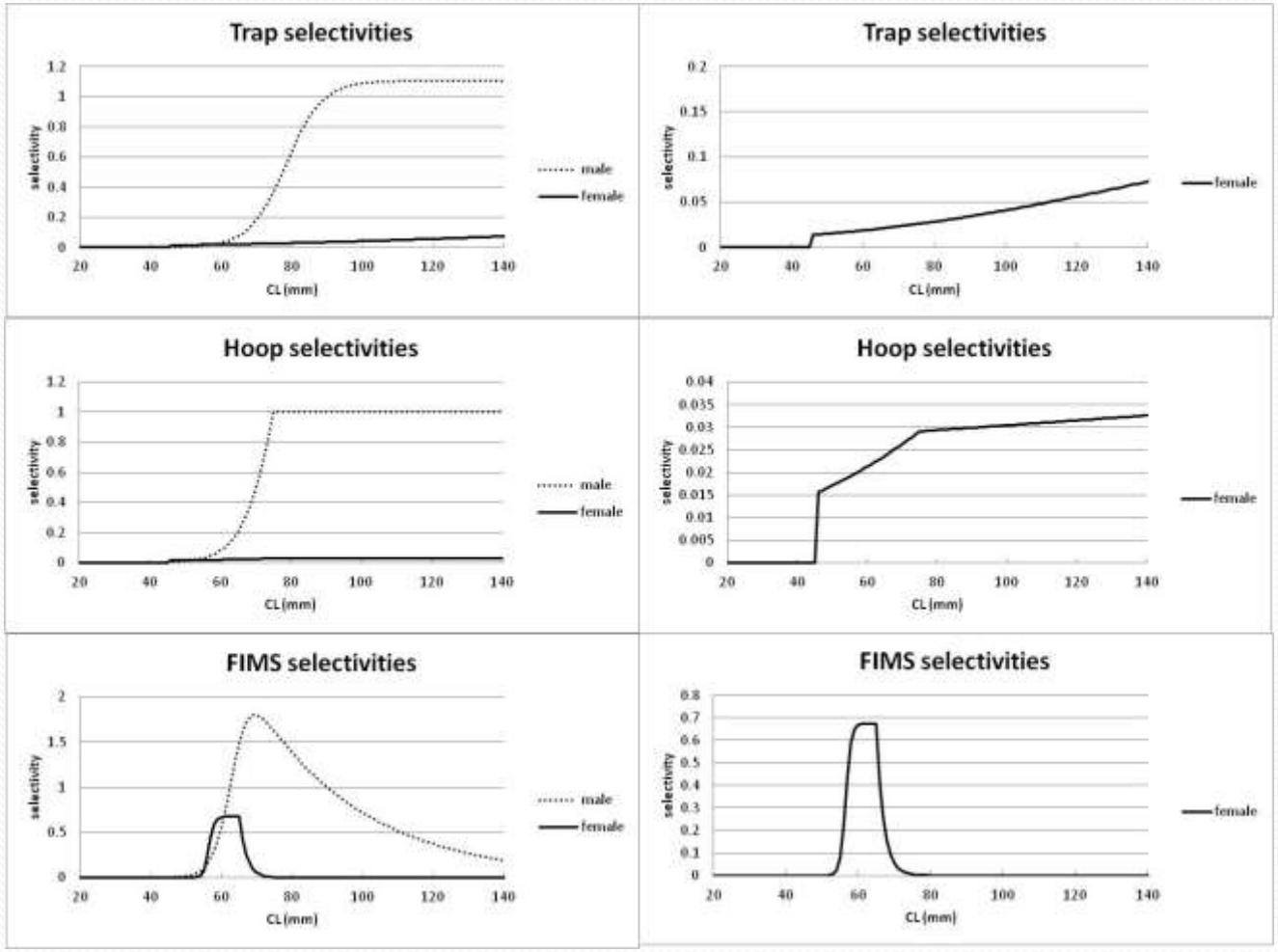
West Coast rock lobster CAL (Area 8)

FIMS = Fishery Independent Monitoring Survey



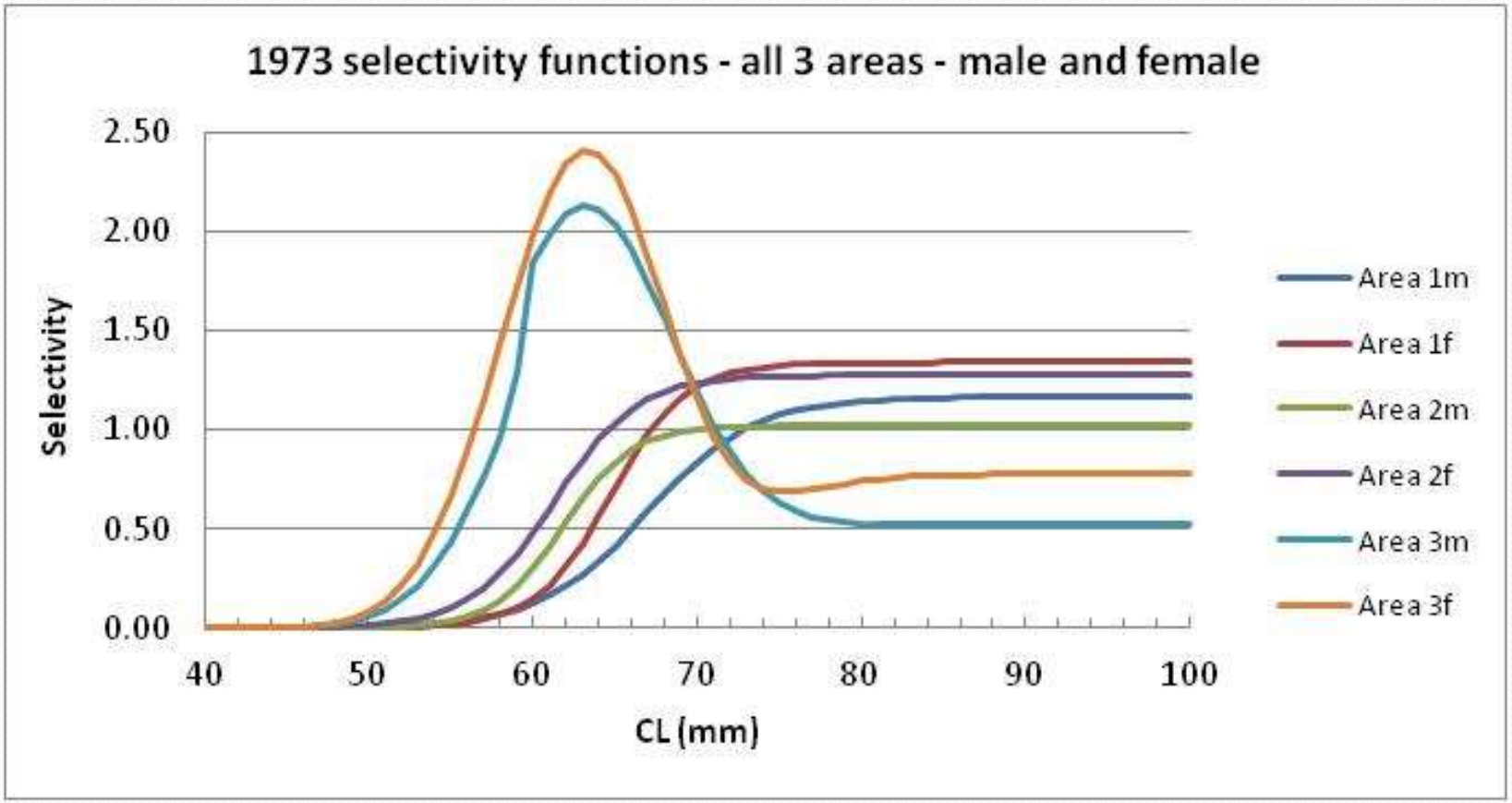
For simplicity trap/hoop large age male selectivity forced flat.

West Coast rock lobster selectivity



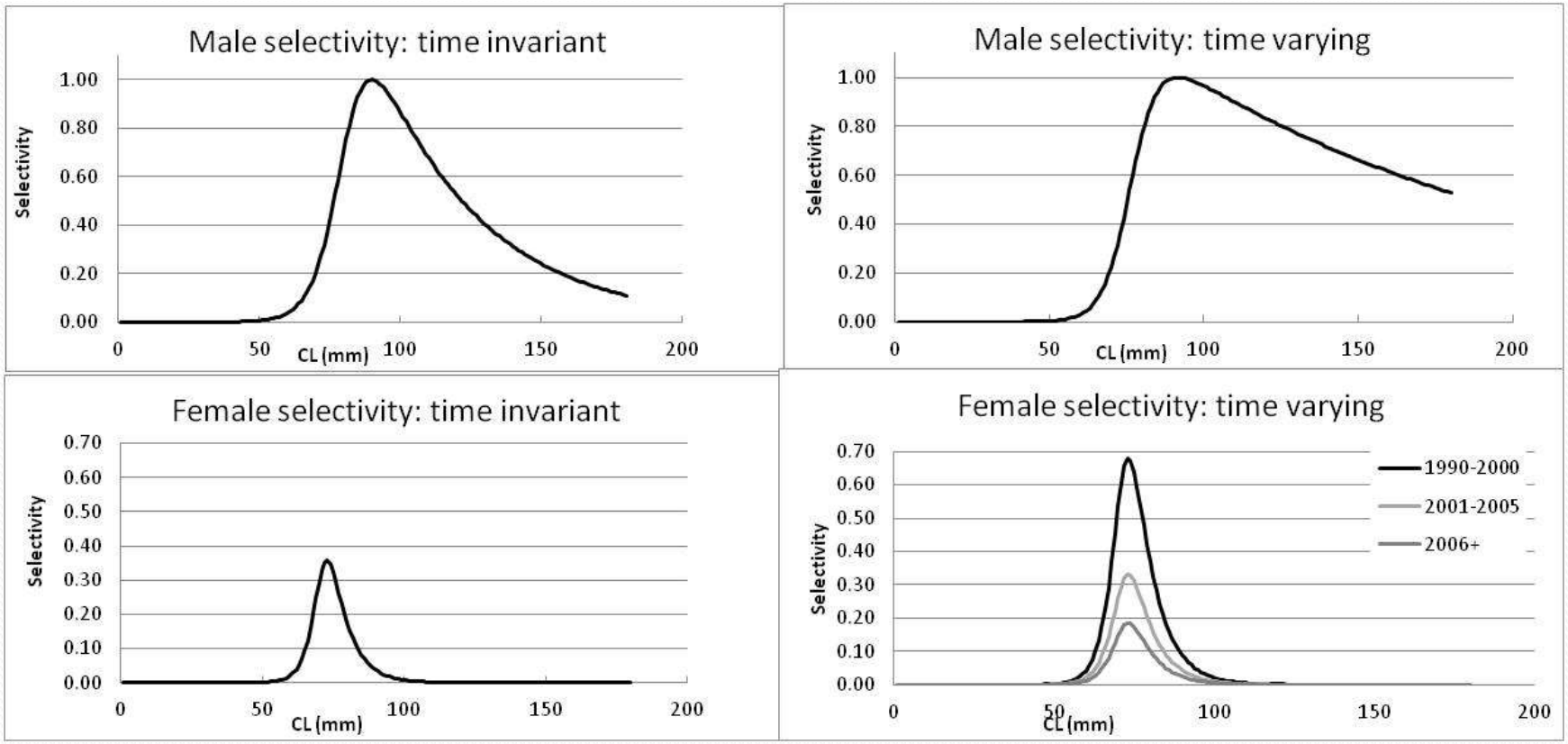
FIMS intended as random sample.

South Coast rock lobster selectivities



Year-dependent length-at-inflection for ascending limb.

Tristan rock lobster selectivities



Doming unavoidable for realistic *M*, though growth uncertain.

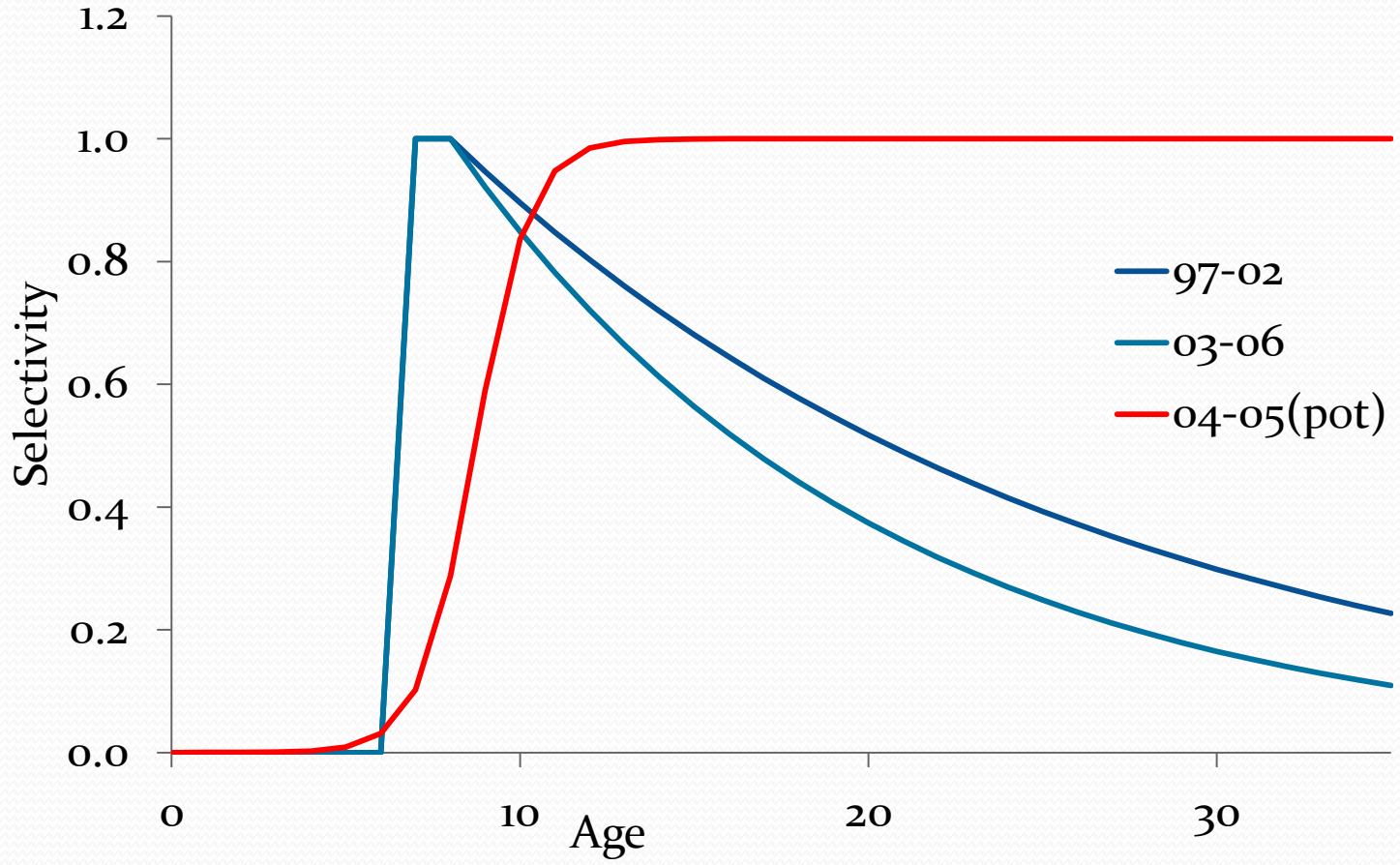
LOBSTERS: In Summary

- Selectivity estimation is difficult, though there are indications of doming in a number of cases.
- The mechanisms underlying the doming are unclear.
- Despite these uncertainties, robustness testing for alternative selectivity assumptions has not played a major role in MP evaluation – why?
  - Performance impact is rather less than other concerns
  - West coast – recruitment and somatic growth dominate
  - South Coast – CPUE and SCAL data conflict impact on status estimation dominates

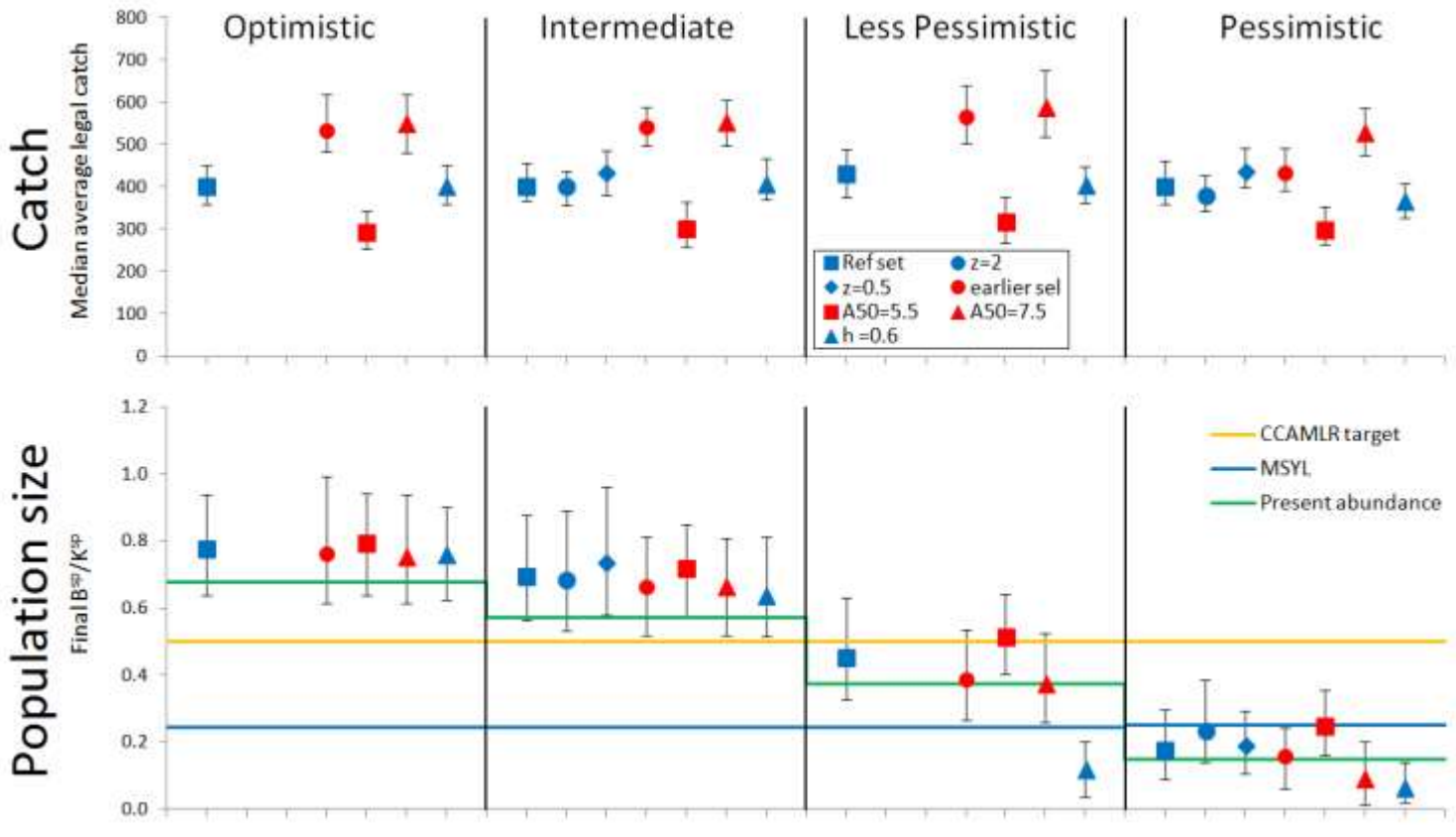
PRINCE EDWARD ISLANDS TOOTHFISH - MP

- Sub-Antarctic Islands under SA jurisdiction
- Heavy IUU fishing prior to legal fishery
- CPUE and CAL data conflict, rendering status evaluation problematic
- Simple empirical MP based on recent CPUE trend and catch mean length relative to “target” level
  - Primary objective is robustness to status uncertainty
- Other key uncertainties are longline selectivity and extent of cetacean depredation

Longline selectivity



MP projections for alternative assessments



Projected median (and 90% PIs) of the average annual legal (longline) catches of toothfish (in tonnes) for the period 2007 to 2026 and the spawning biomass depletion at the start of 2026 for the four Operating Models (OMs) for various robustness tests.

TOOTHFISH – In Summary

- Broadly similar to lobster situation
- Clear evidence of selectivity doming
- Another instance of CPUE vs CAL conflict
- Though alternative selectivity assumptions do impact MP performance, MP selection is dominated by ensuring robustness to resource status uncertainty arising from CPUE/CAL conflict

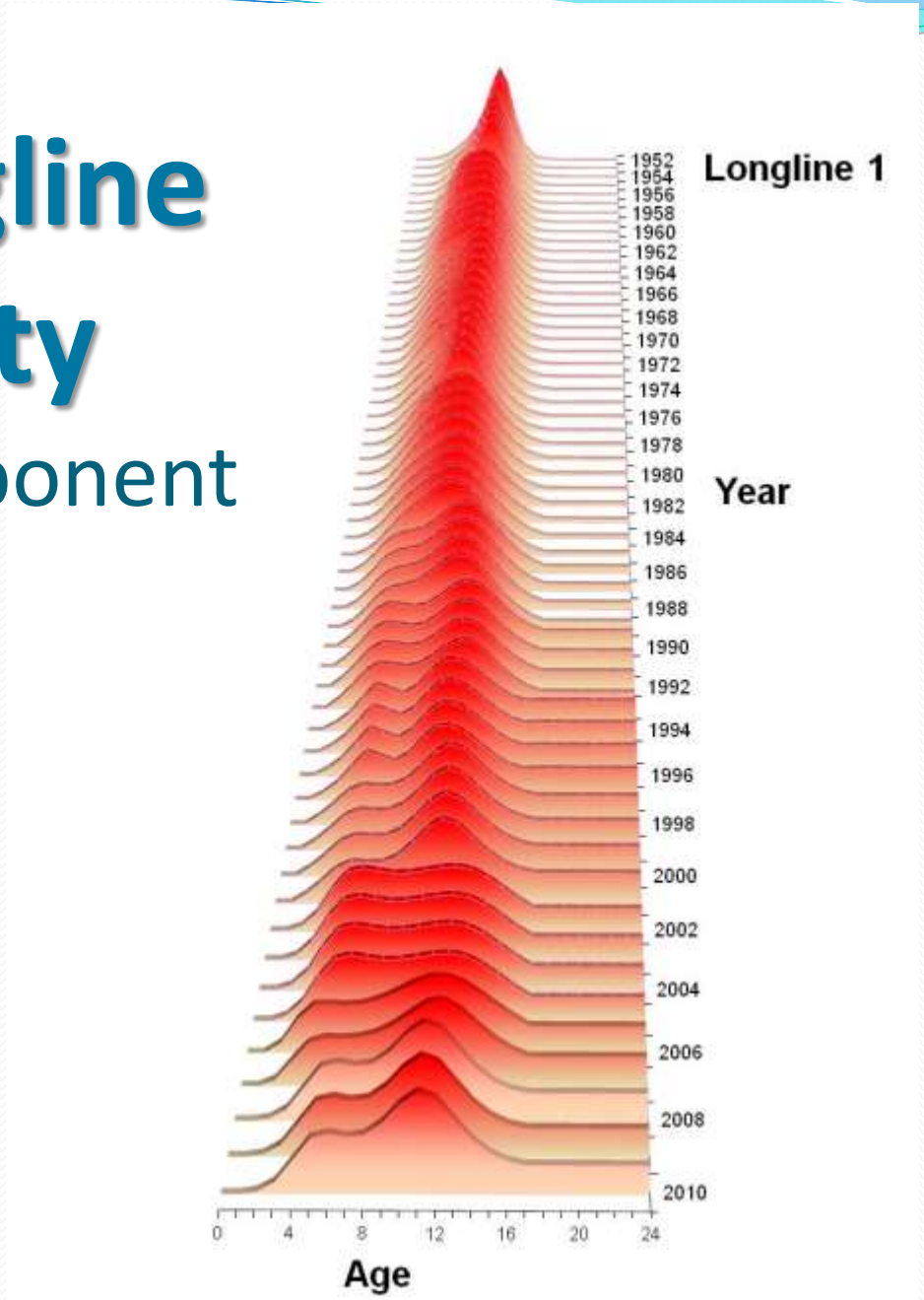
SOUTHERN BLUEFIN TUNA - MP

- Highly valuable, contentious and depleted international fishery
- MP basis to guide recovery recently agreed
  - Combination model + empirical MP
  - Data used: Japanese longline CPUE (ages ~ 5-10 pre-spawning)
    Australian bight aerial survey (ages ~2-4)
- Seven factors in Reference Set of OMs

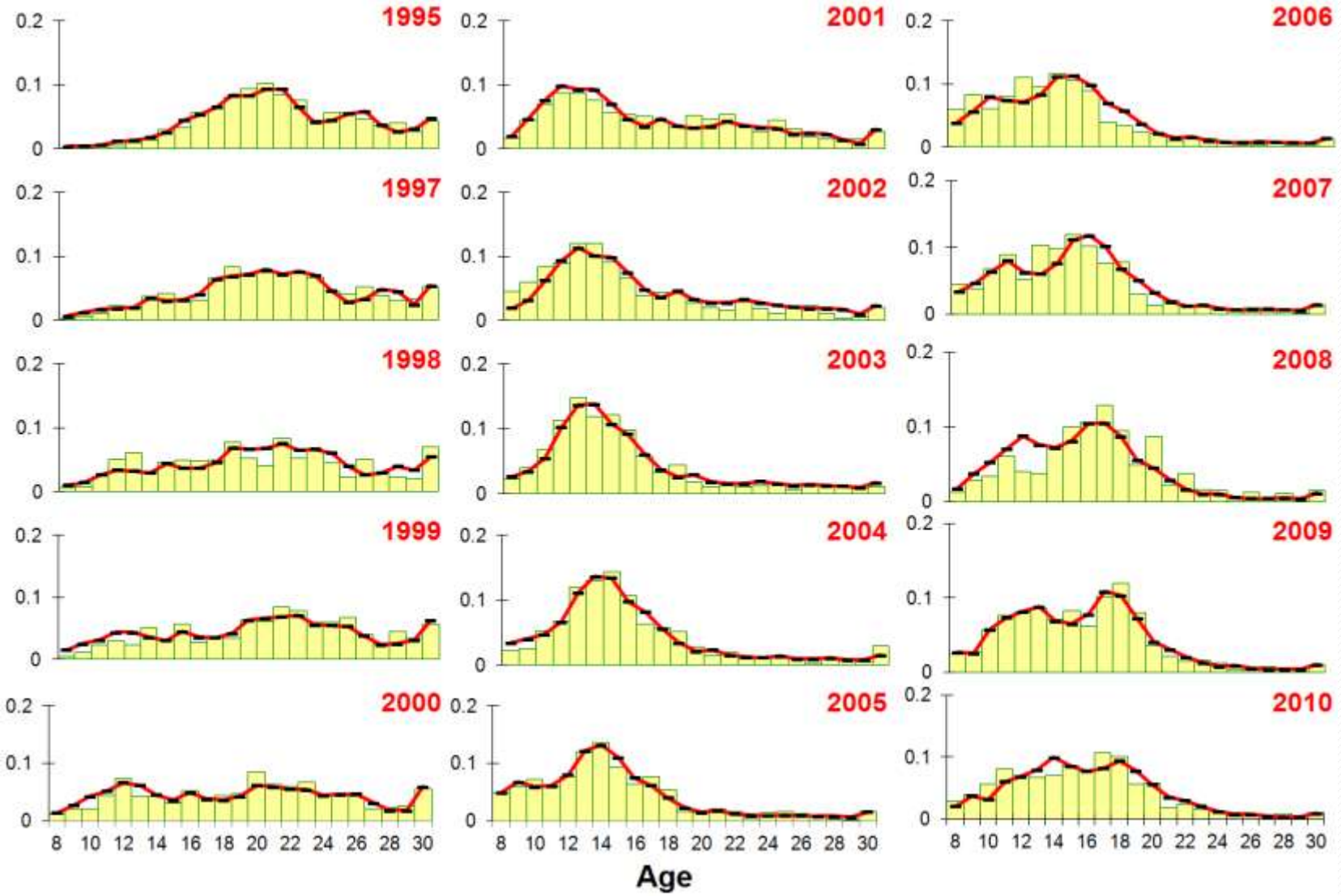
  S/R steepness h ; M_1 and M_{10}
  CPUE non-linearity and area-weighting
  q definition with time-varying selectivity
  Relative weighting of different CPUE series

SBT longline selectivity

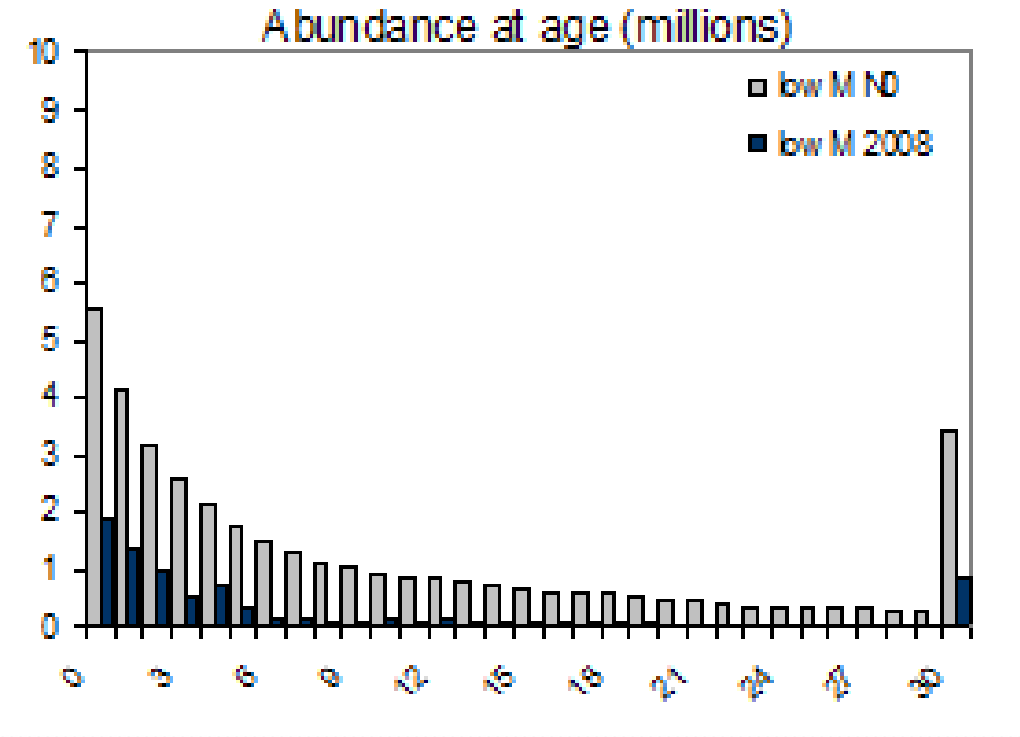
Major component of catch

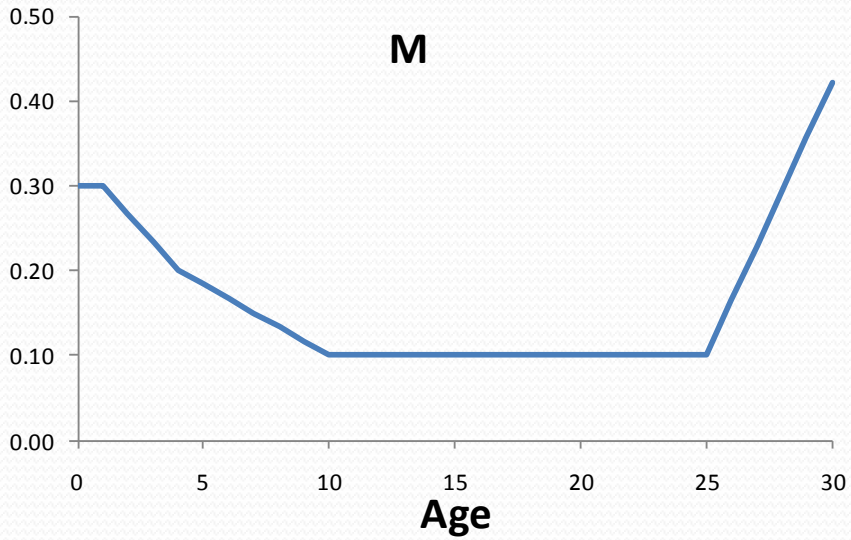


SBT Indonesian bycatch CAA fits



SBT age-dependent natural mortality





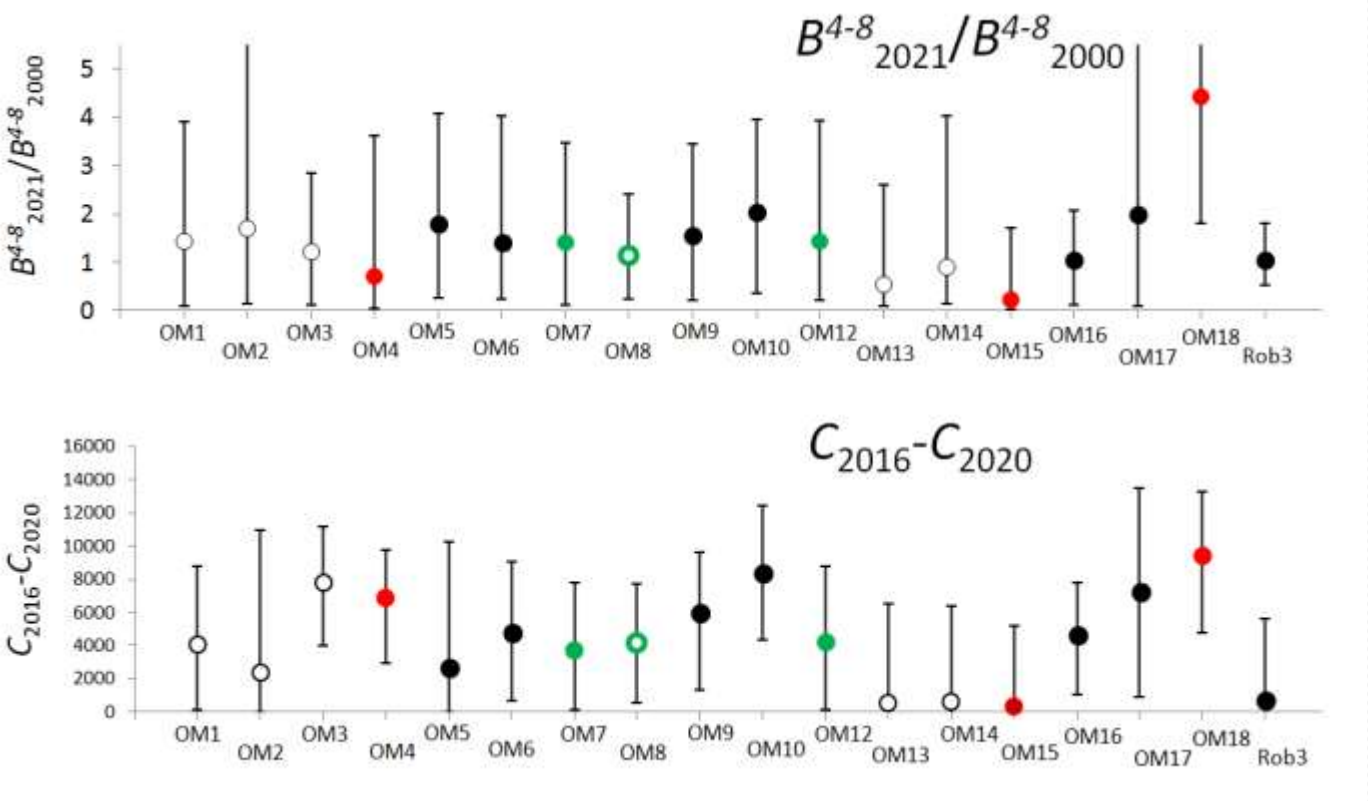
SBT – In Summary

- Domed selectivity clearly is present for age-specific distributional reasons
- Nevertheless domed selectivity alone is not seen as a realistic explanation for spawner bycatch fishery age structure, as it implies large cryptic biomass
- Hence increasing *M* at larger ages introduced too
- Steepness and *M* uncertainties dominate
- Explicitly selectivity uncertainty (through *q* definition) has little impact on MP performance, though *M* uncertainty is partly surrogating selectivity uncertainty

CANADIAN POLLOCK - MP

- Fishery characterised by high recruitment variability and a high variance survey
- Empirical MP based on the survey index
- MP selection dominated by catch *vs* resource risk trade-off across Reference Set averaged over a balanced set of six OMs, with 13 other robustness tests also considered
- Selectivity generally assumed flat at older ages, but one case of doming considered, as well as alternative *M* scenarios
- Other robustness tests included alternative future recruitment assumptions, as well as non-linear survey *vs* abundance relationships

Canadian pollock MP – robustness tests



95% PIs shown

Open circles show Reference Set inclusion

● selectivity, natural mortality

● recruitment, non-linear survey-biomass relation

CANADIAN POLLOCK – In Summary

- MP performance was impacted primarily by assumptions related to future recruitment and possible non-linear survey *vs* abundance relationships

- By comparison tests involving alternative selectivity or natural mortality assumptions had relatively little impact

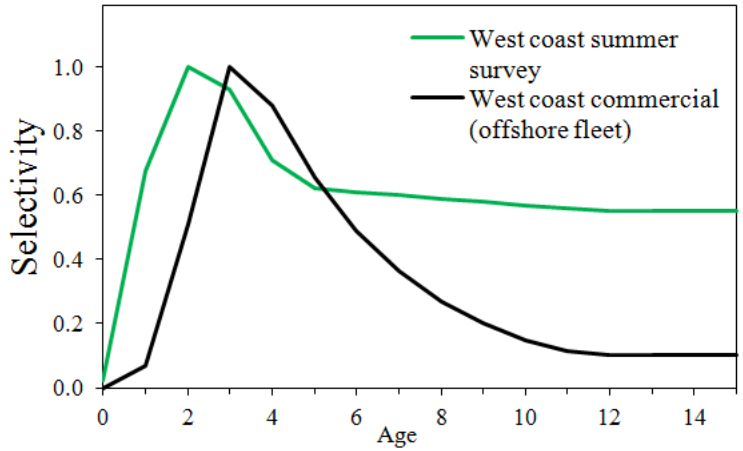
SOUTH AFRICAN HAKE - MP

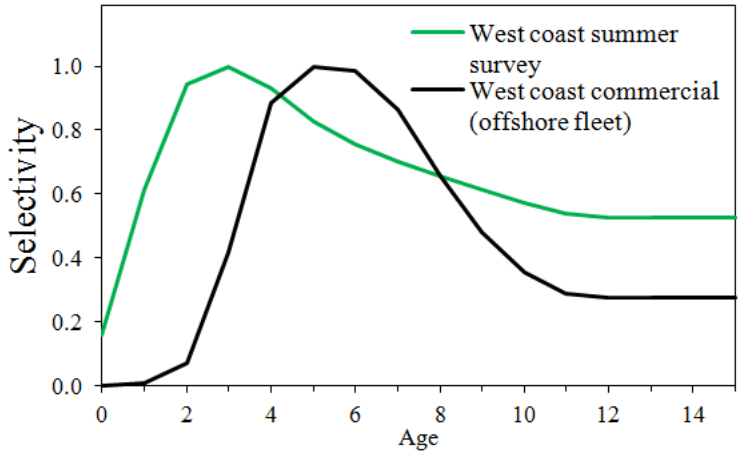
- Consists of two overlapping species: *M. capensis* (shallower water) and *M. paradoxus* (deeper water), not distinguished in the commercial catch
- *M. capensis* > *B*msy ; *M. paradoxus* < *B*msy

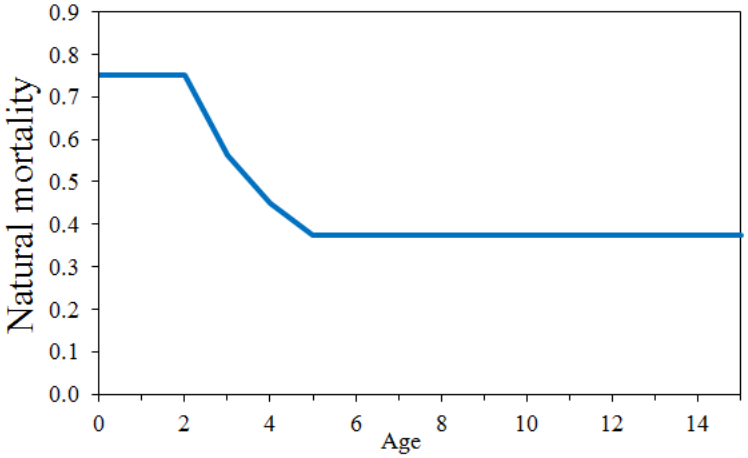
  Priority is to recover *M. paradoxus* to *B*msy
- More important uncertainties:
  - S/R relationships
  - *M* and its age dependence
  - Split of pre-1978 between species
- Reference Set of 12 OMs to cover important uncertainties plus many other robustness tests

SOUTH AFRICAN HAKE SELECTIVITIES

Reference Case





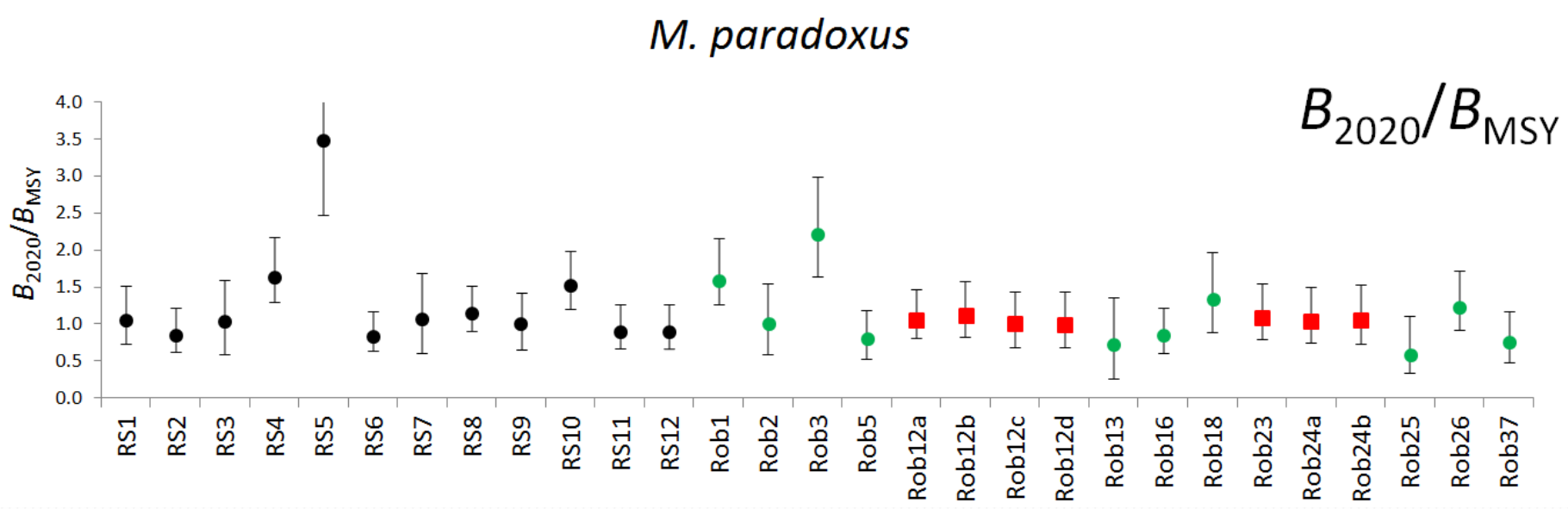


Survey

Commercial

SOUTH AFRICAN HAKE MP

Robustness tests – *M. paradoxus*



95% PIs shown for empirical MP based on recent CPUE and survey indices

Black circles show Reference Set (historic species split of the catch, natural mortality, recruitment function)

- selectivity, natural mortality
- past catches, changes in *K*, start year, maturity function

SOUTH AFRICAN HAKE – In Summary

- MP performance is mainly sensitive to S/R aspects and natural mortality, with changes in *K* the most important amongst the robustness tests
- Selectivity is clearly domed for both the commercial fishery and the surveys, and for both species
- Alternative selectivity specifications had little impact on MP performance, though the somewhat more influential alternative M scenarios are surrogating for selectivity to some extent

GREENLAND HALIBUT - MP

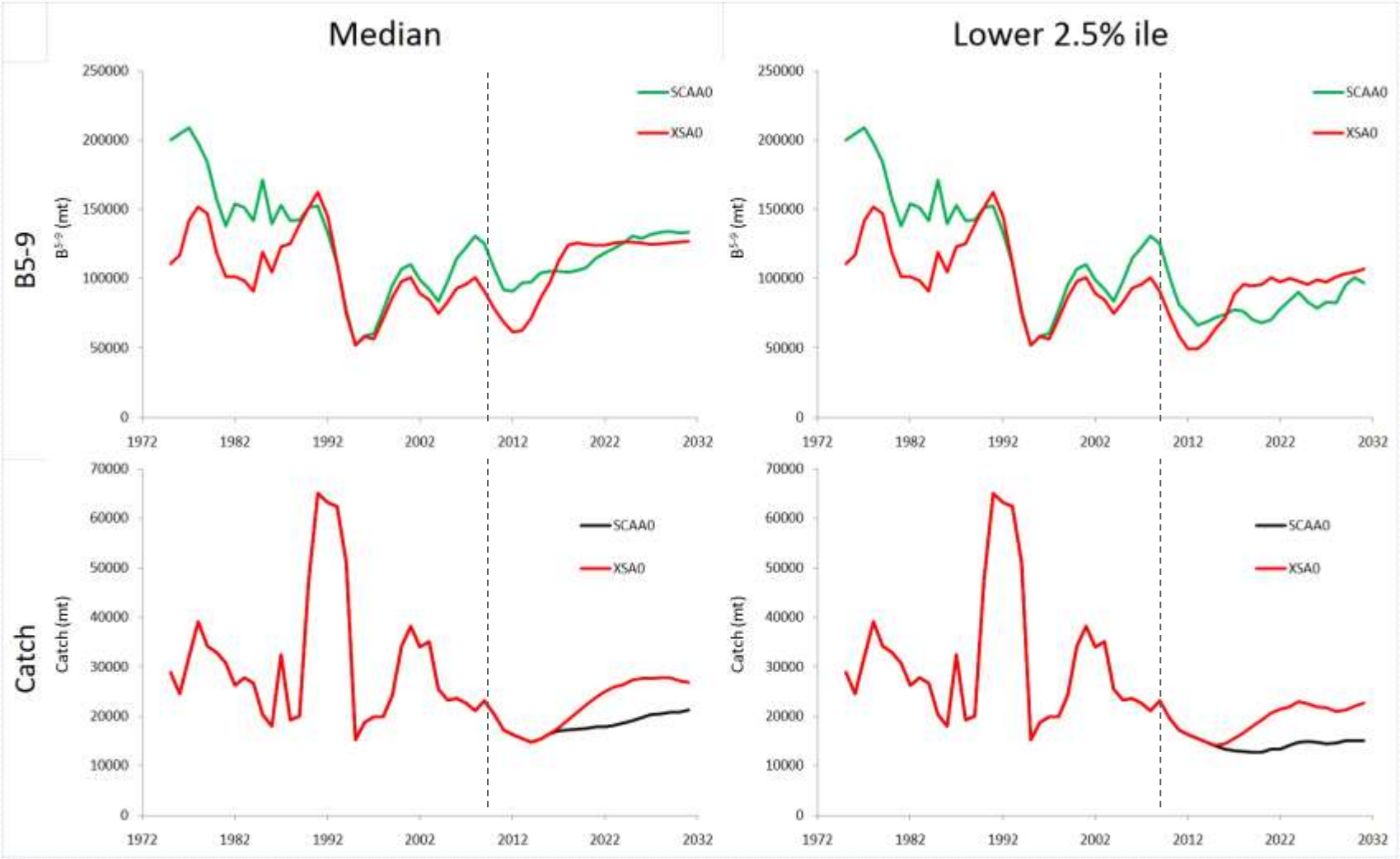
Two assessments: XSA and SCAA

Empirical MP based on recent trend in surveys

- SCAA0: RC (domed)
- SCAA1: flat comm sel (est)
- SCAA2: flat comm sel (XSA)
- SCAA3: *M*=0.1
- SCAA4: *M* incr. at older ages
- SCAA5: *h*=0.6
- SCAA6: Ricker
- SCAA7: flat comm sel, incr *M*

- XSA0: RC (flat)
- XSA1: *M*=0.1
- XSA2: dome
- XSA3: *M* incr. at older ages
- XSA4: recruitment-overfished
- XSA5: recruitment-overfished, *M*=0.1

Base Case SCAA vs XSA under mp14

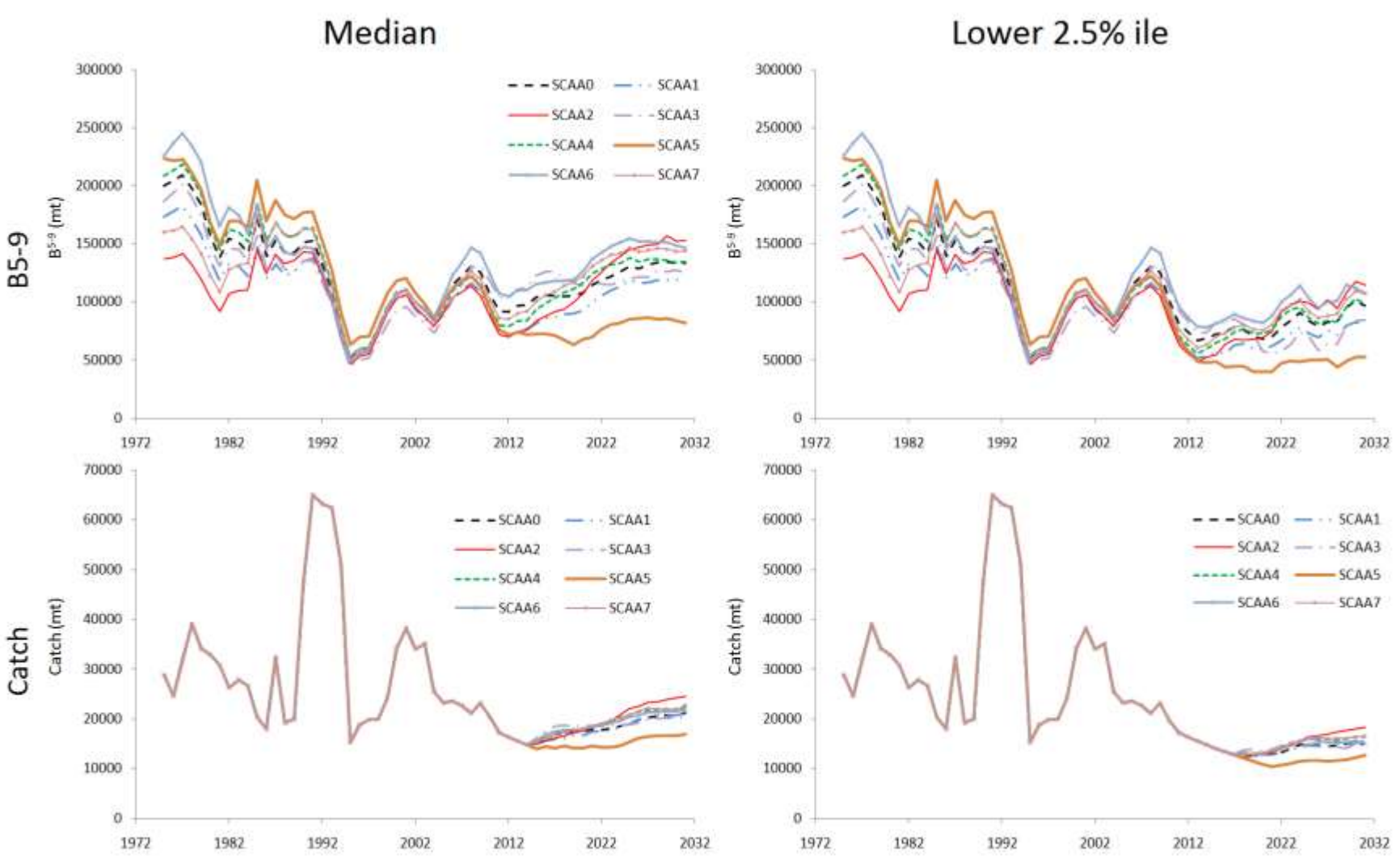


mp14 across SCAA and XSA Base Cases and robustness tests

mp14	Prob. of B^{exp} decline of >25% from 2011-2016	Prob. of TAC variability >25% over any period of 3 yrs	Magnitude of av. TAC (2011-2030)	Prob. of failure to meet milestone*
Target	<10%	<25%	max	<25%
SCAA0	2%	14%	18102	20%
SCAA1	**4%**	**17%**	**17816**	**22%**
SCAA2	**2%**	**22%**	**19198**	**1%**
SCAA3	2%	17%	18329	17%
SCAA4	2%	17%	18776	27%
SCAA5	14%	11%	15366	100%
SCAA6	2%	17%	18598	6%
SCAA7	**2%**	**17%**	**18849**	**16%**
XSA0	0%	22%	22158	0%
XSA1	0%	28%	24794	0%
XSA2	**0%**	**17%**	**21482**	**13%**
XSA3	0%	17%	21202	9%
XSA4	0%	39%	25180	0%
XSA5	0%	47%	27528	0%

* milestone: av. B^{exp} for 1985-1999 to be compared to B^{exp} in 2031

mp14 across SCAA Base Case and robustness tests



GREENLAND HALIBUT – In Summary

- MP performance is very sensitive to (effectively) lower steepness S/R relationships
- Domed selectivity (under SCAA) gave higher recent biomasses, so these OMs were expected to provide easier tests than those based on XSA (with flat selectivity)
- To the contrary, candidate MPs experienced the greater difficulty in meeting pre-agreed performance targets for certain of the SCAA-based tests than for the XSA-based tests
- The reason is that with the higher spawning biomass associated with the domed selectivity, the same change in catch has lesser impact on the abundance trend, i.e. there is more inertia in the dynamics

IV. SUMMARY IMPRESSIONS

NB: IMPRESSIONS from a wide-ish experience, **NOT CONCLUSIONS** from an exhaustive analysis

SELECTIVITY FOR EARLIER AGES

- Problems with estimation and time-dependence
- Consequently problems with defining *q*
- However these do not seem of major importance for management
- There is in any case confounding with specification or estimation of *M* and its age- and time-dependence

SUMMARY IMPRESSIONS

SELECTIVITY FOR OLDER AGES

- Issues arise from the relative paucity of older/larger fish in catches and/or surveys, for which heavy *F* at those ages/lengths is not the only possible explanation
- Analyses ubiquitously point to at least some selectivity doming, with the underlying mechanisms not always clear
- This can sometimes have important implications for BRPs and associated management advice
- Those BRPs are unlikely to be robust to alternative explanations of domed selectivity, higher *M*, or increasing *M* at larger ages

SUMMARY IMPRESSIONS

MANAGEMENT PROCEDURES

NB: In frequent practice, limitations of time have led to MP robustness testing not being as comprehensive as desirable for examples given

- Even when there is evidence for domed selectivity, uncertainties regarding selectivity are generally **NOT** the factors to which MP performance is the most sensitive
- Selectivity/Natural mortality estimation may be more pertinent to the rate at which recovery can be achieved
- A larger problem perhaps is instances of conflicts between abundance indices and CAA/CAL data, where typically the former indicates a decline but the latter do not – are explanations of pre-exploitation recruitment anomalies convincing?

SUMMARY IMPRESSIONS

SOME HERESIES IN CONCLUDING

- Is there a more fundamental problem for management?
- In the absence of reliable specification or estimation of *M* and its age-dependence, and hence also of selectivities, should we have confidence in estimates of age-based BRPs including those related to MSY (or its proxies)?
- Should we abandon the MSY concept for management, and rather choose (recovery) targets on the basis of the socio-economic trade-offs between losses today compared to gains later (*a la* SBT)?
- Was de la Mare:

"I produced the package to show that selections for these parameters don't matter"

more right than wrong generically?

Thankyou for your attention