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Note on the 1983-2010 skipjack activities of EU PS in the Indian Ocean

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Visible and cryptic indicators related to SKJ stock & fisheries, to keep in mind in the estimation of SKJ biomass based on PS CPUE

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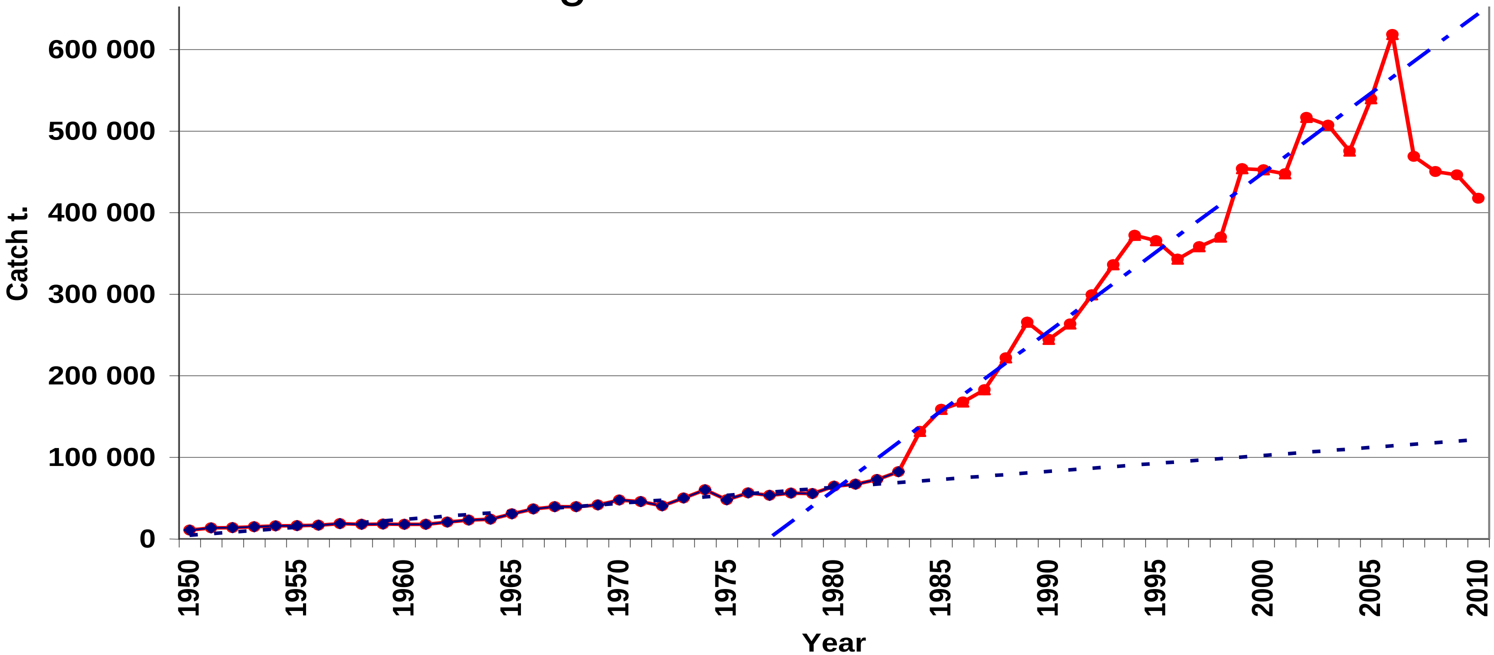
GLM SKJ CPUEs & indicators

- Theoriticaly standardization procedures of PS CPUEs tend to be based on a simplified limited set of well known parameters that are important in calibrating over time the efficiency of different vessels accounting for factors such as size of the vessel, fishing modes, spatio-temporal heterogeneity of fishing effort, etc..
- However practice showed that in most cases they face serious difficulties to incorporate other important parameters that are poorly documented, difficult to estimate, or difficult to incorporate in the GLM models, such as increase in fishing power, changes in species targetted & other cryptic parametersinvolved in the targeting of a given species.
- In complement of statistical standardization procedure that are done independently, this technical note will examine and discuss a wide range of indicators and external information that are potentially related to the fishing efficiency of EU purse seiners on SKJ, and to the fishing mortality suffrede by the SKJ stock, many of them being absent in most of the present GLM indexing
- This work will be stratified in 4 parts: (1) indicators based on the public domain IOTC data (catch & effort & sizes of PS), (2) indicators based on the original log books of EU PS, (3) Review and discussion of other factors that are playing a role in conditionning the efficiency of EU PS and their CPUE, (4) Conclusion, upon the present SKJ stock status, solely based on this overview of SKJ indicators.

Part 1: Changes in the PS SKJ fishery that are important relevant to condition SKJ CPUEs & easily visible calculable: based on IOTC fishery data

1) Yearly total SKJ catches all gears & countries , figure 1
2) Yearly nominal fishing efforts by PS , figure 2
3) Total SKJ Fishing effort estimated from PS efforts, , figure 3
4) Yearly SKJ total catches by PS, by country, figure 4
5) Yearly % of SKJ in total catches by country, figure 5
6) % of SKJ in the FAD associated catches , figure 6
7) % of SKJ catches on FADs vs total SKJ catches , figure 7
8) Quarterly seasonality of SKJ catches , figure 8
9) SKJ CPUEs of PS: EU & Spanish+Seychelles, total , figure 9
10) SKJ CPUEs of PS: EU & Spanish+Seychelles, on FADs , figure 10
11) Changes in the total sizes of the SKJ areas fished by EU PS: yearly and monthly , figure 11
12) Figure 12: 1990-1995, birth of FADs , figure 12
13) Numbers of 1° squares fished for SKJ, figure 13
14) Average SKJ catches of PS by 1° squares fished yearly, figure 14
15) Basic SKJ maps to keep in mind, Figure 15:
16) Changes in the SKJ concentration patterns: ie, SKJ Gulland's Index , figure 16
17) Visible Negative effects due to Somalian piracy: loss of SKJ fishing strata, Figure 17 a&b
18) Changes in SKJ size caught by the Indian Ocean fisheries: average weights caught yearly by PS & BB, figure 18 a to f
19) Average SKJ catches, CPUEs and effort in the best SKJ strata, by 5° and month, figure 19 a-c
20) SKJ taken on free schools by EU PS: Figure 19d:

Figure 1a: total SKJ catches

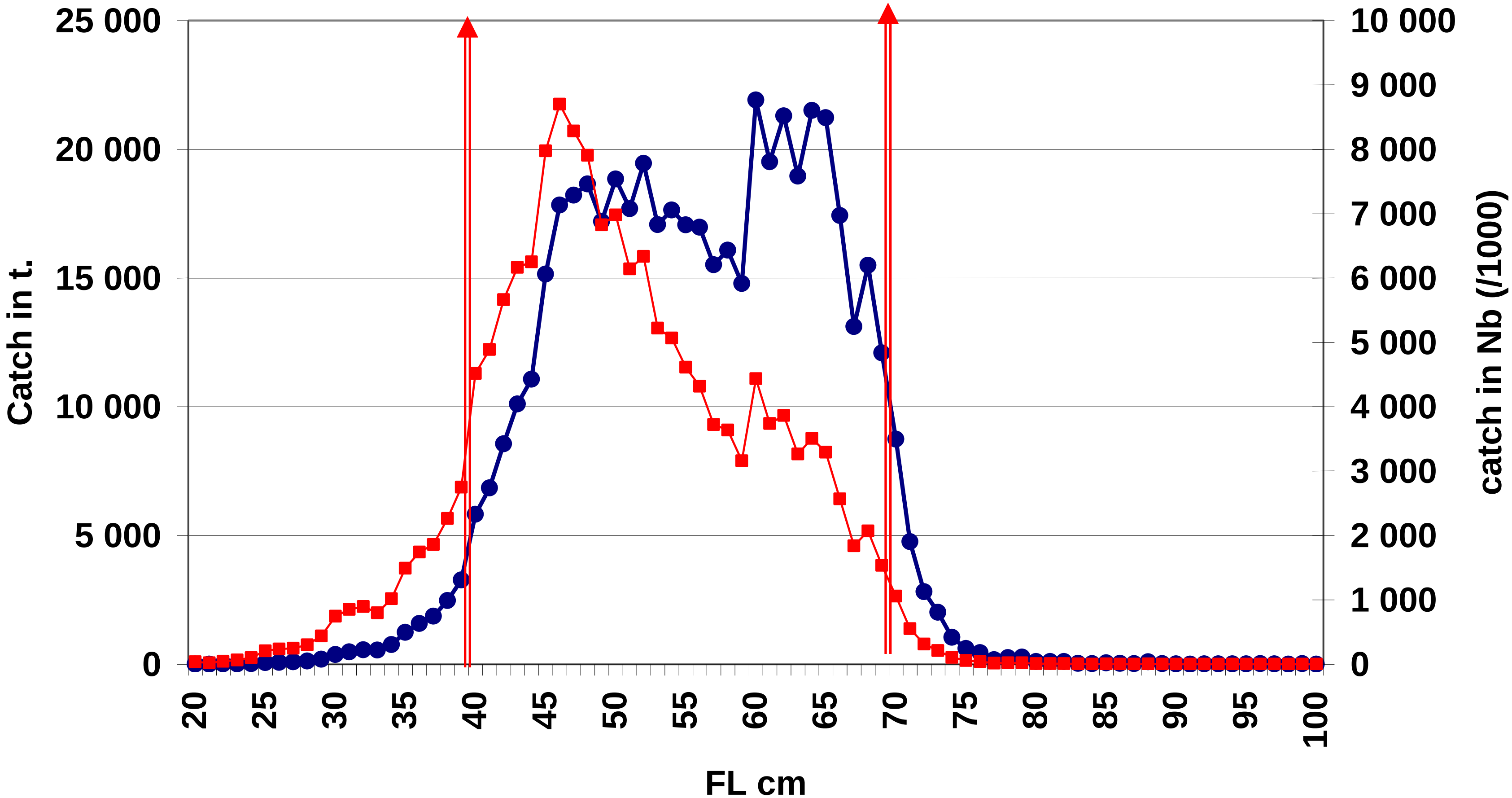


1) 1950-1983: 35 years of increasing but low SKJ catches: average catch=36.600t
2) 1984-2006: 22 years of major linear increase in the SKJ catches: average catch=351.000t
3) 2007-2010: declining but high SKJ catches: average catch=446.000t

These changes in total catches would easily allow to hypothesize that:

a) Period 1950-1983: the exploitation rates of the SKJ stock were low and its biomass high, close to a virgin stock
b) Period 1984-2006: permanent increase of exploitation rates producing steadily declining biomass (at an unknown rate?)
c) Period 2007-2010: still high exploitation rates, & the decline of total catches can be due: either to declining exploitation rates (lower effort or/and lower stock catchability) or to stock overfishing.

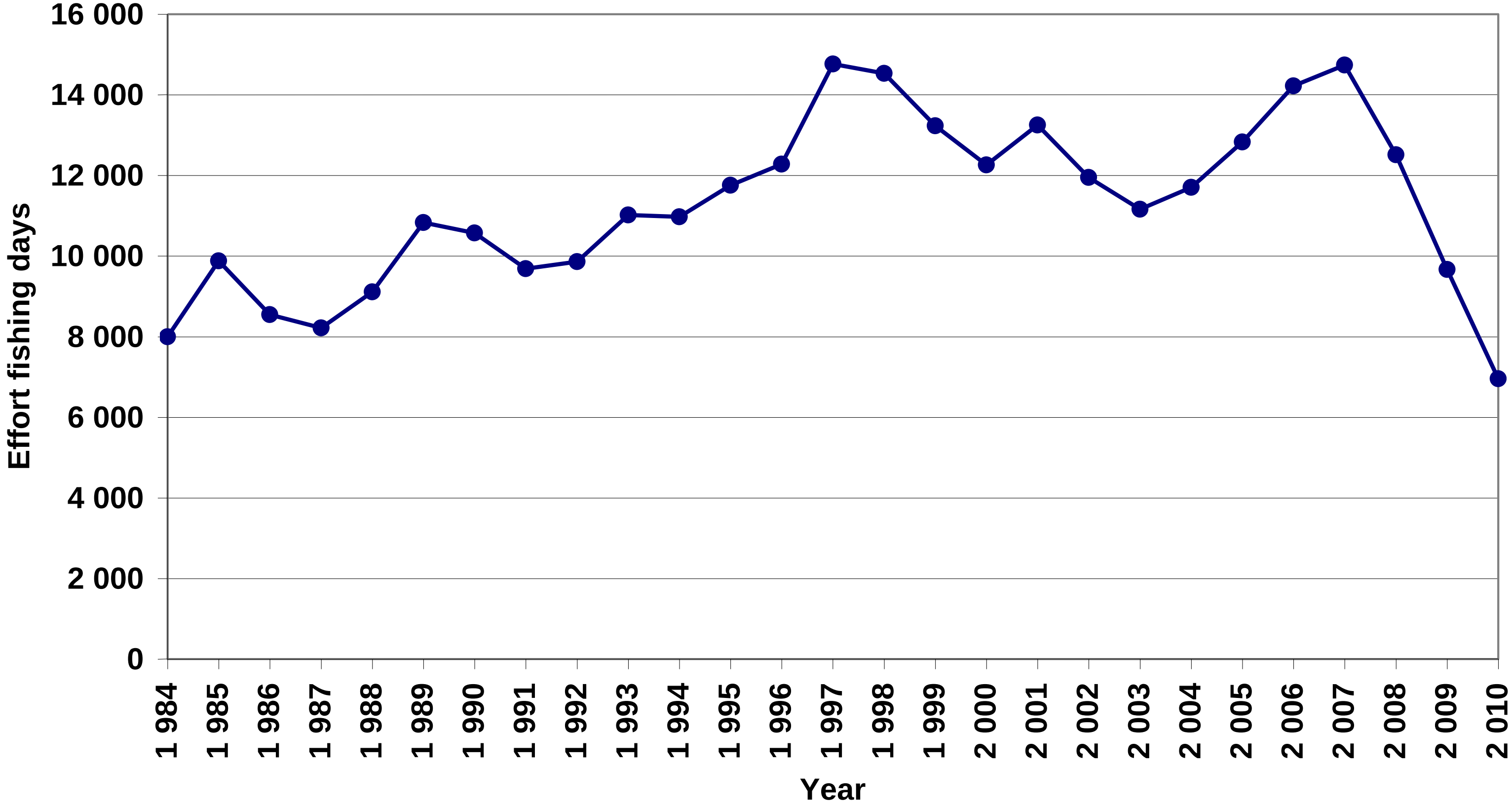
Figure 1b: Average total CAS of SKJ, in weight



- Combined fisheries dominated in weight by SKJ between 40 & 70 cm

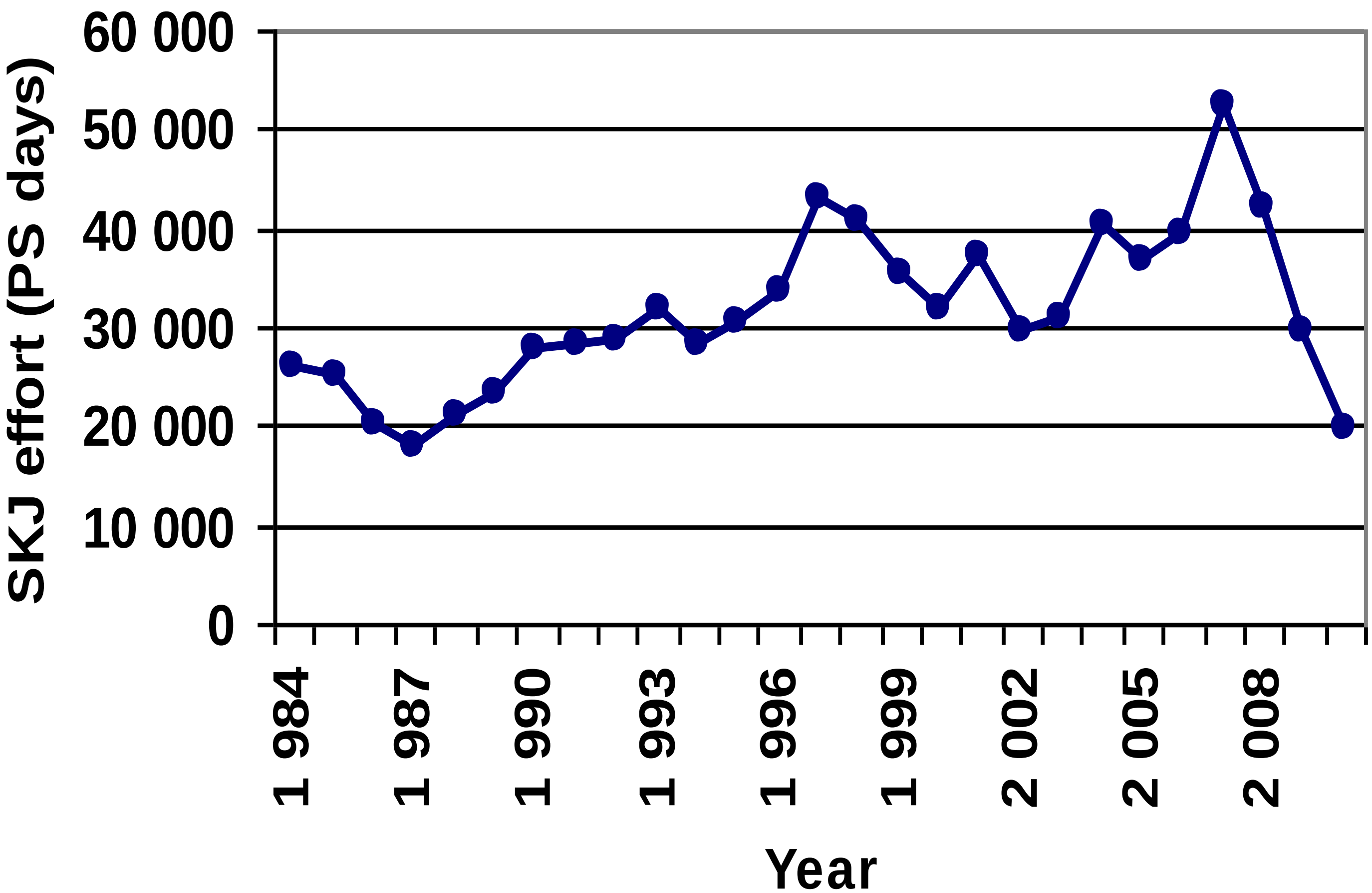
-SKJ <40 cm and >70 cm play a minor quantitative role in fisheries

Figure 2: Total fishing efforts by EU PS



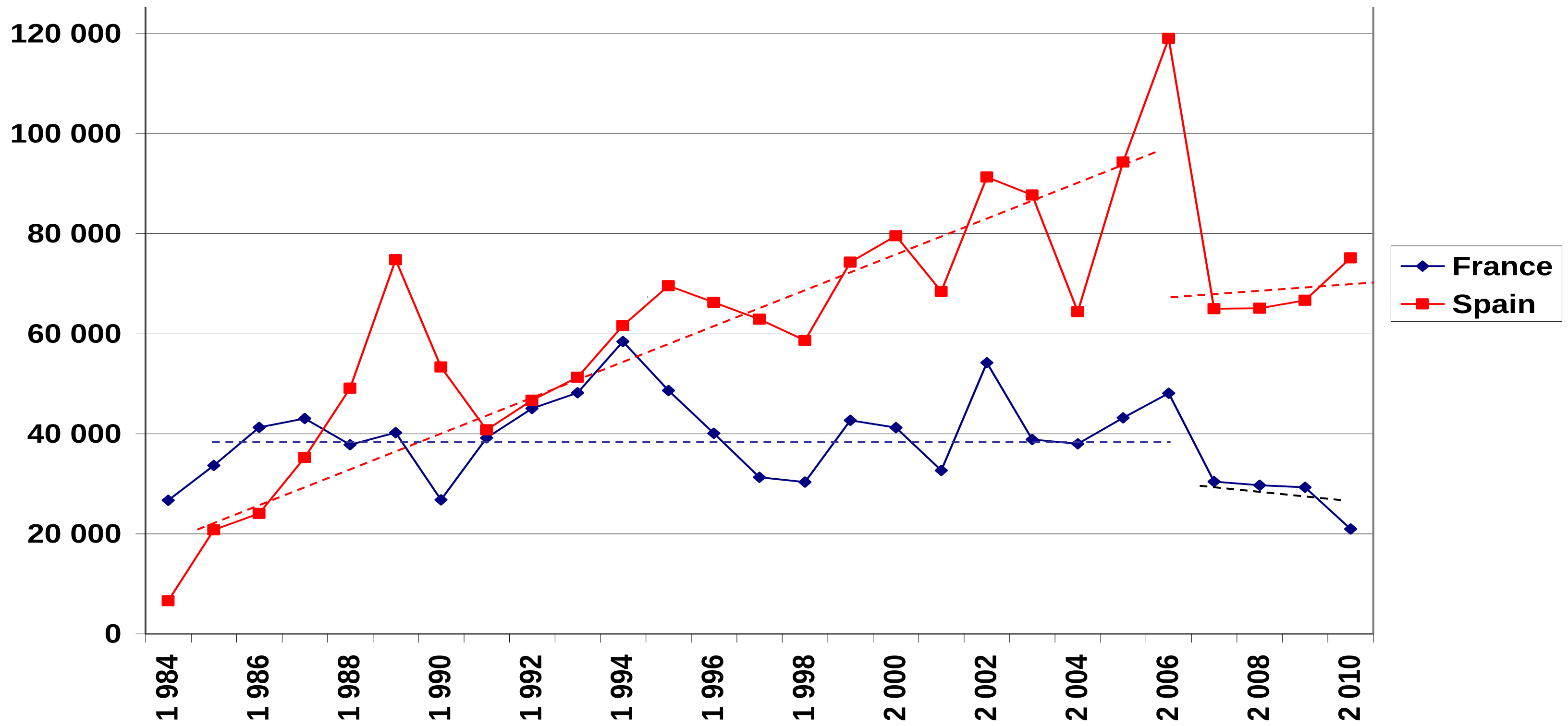
-1984-1987: period of slowly increasing nominal fishing efforts
-1987-2007: period of stable fishing efforts
-1987-2007: period of marked decline in nominal fishing efforts, due to Somalian piracy.

Figure 3: Total SKJ Fishing effort:
estimated from PS efforts * the ratio of total SKJ catches/PS SKJ catches



- ➢Total SKJ nominal fishing effort showing a steady increase between 1984 & 2007:multiplied by a factor > 2.
- ➢Major decline of SKJ nominal effort since 2007

Figure 4: SKJ catches / EU PS: France & Spain+Seychelles

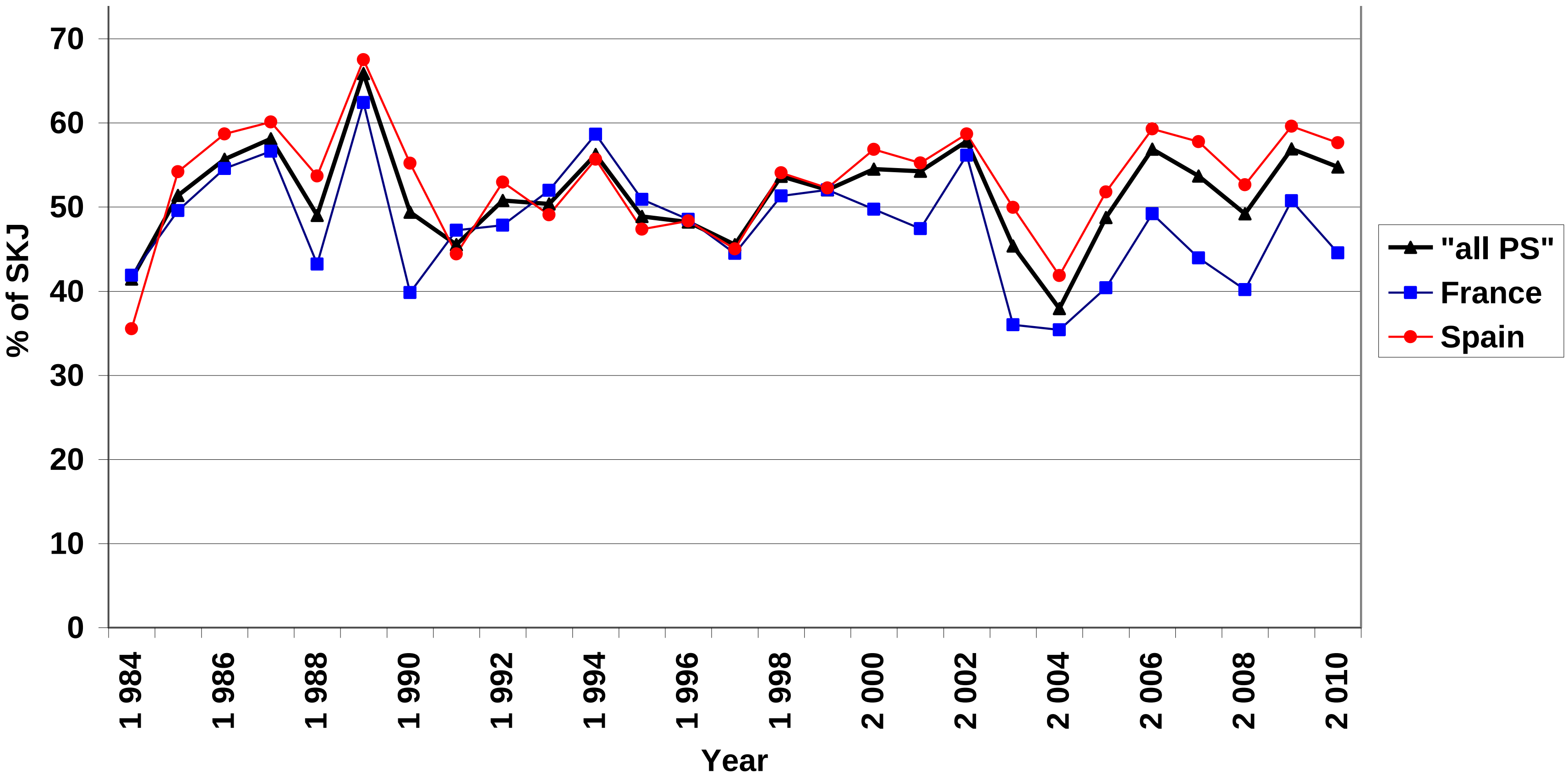


Total catches of SKJ have been:

-France: stable trend during the 1985-2006 period, followed by 4 years of low catches 2007-2010

-Spain+Seychelles: steady increase of SKJ catches during the period 1984-2006, and lower catches in the 2007-2010 period (at levels of the mid nineties)

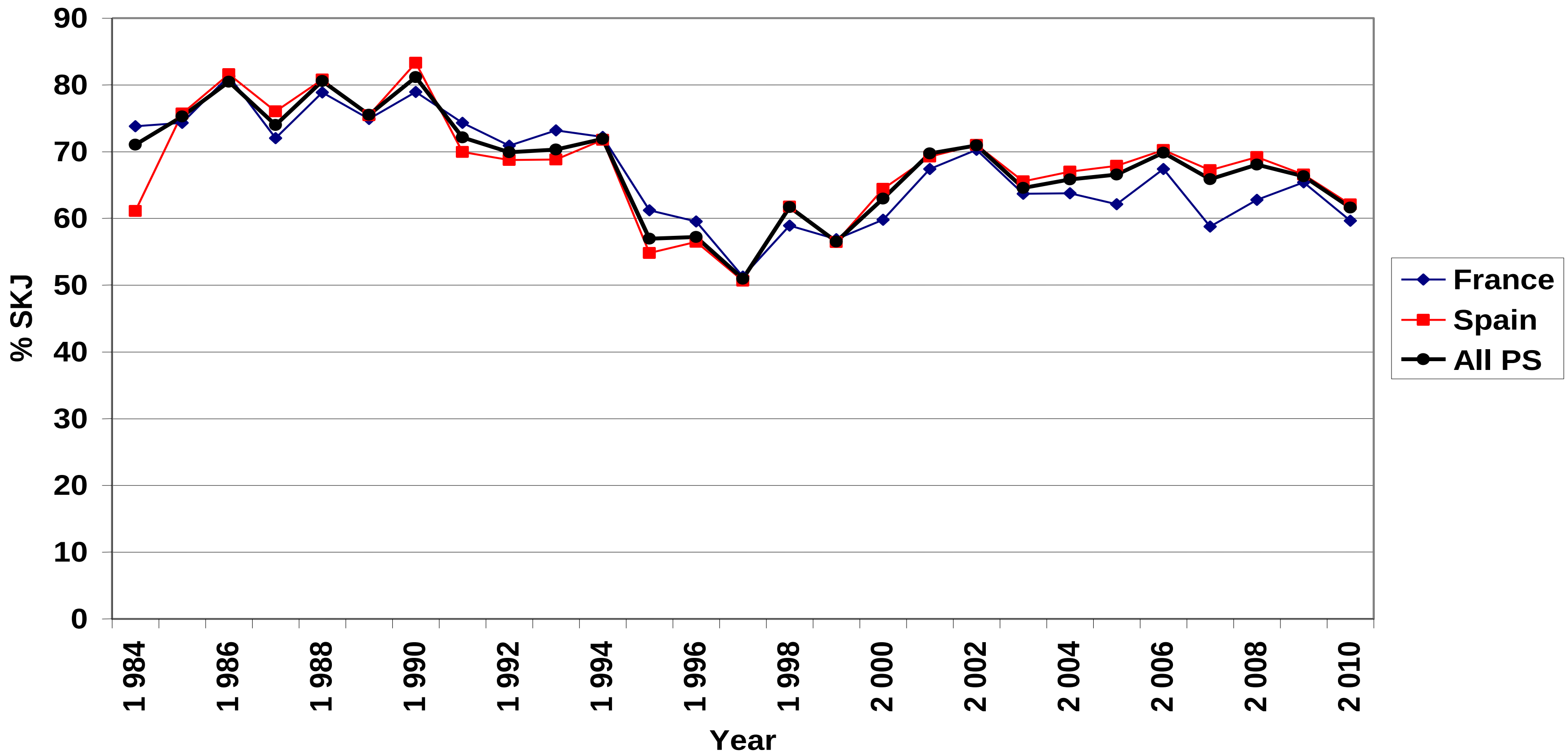
Figure 5: % of SKJ in the total yearly PS catches



➢1984-1999 period % of SKJ in the total catches of PS was nearly identical for all flags & at 50%

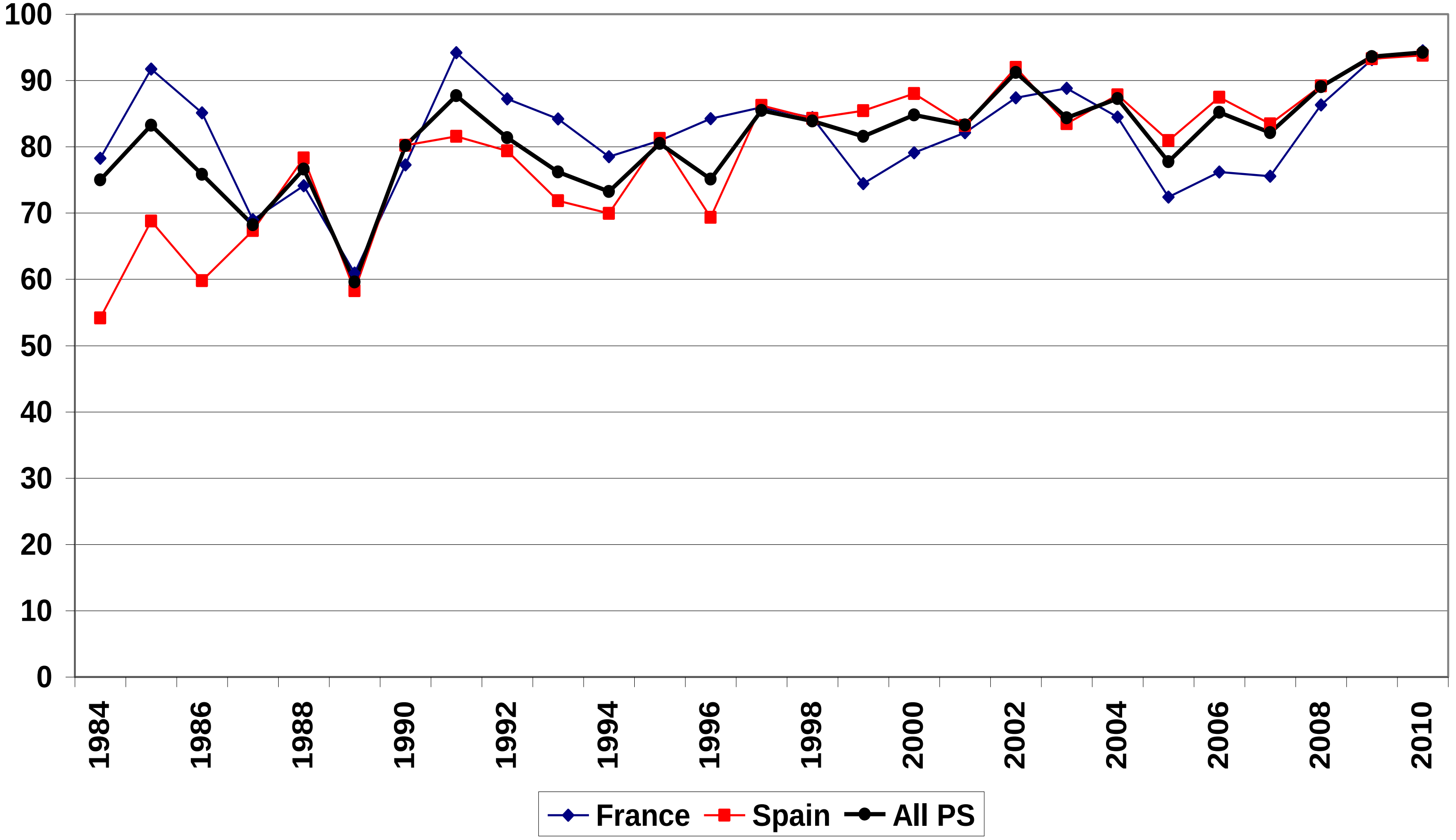
➢2000-2010 period : increasing % of SKJ for Spanish+Seychelles PS (average = 55 %), and declining % of SKJ in the French PS total catches (average = 45 %).

Figure 6: % of SKJ in the FAD associated catches



1) % of SKJ in the FAD associated catches are nearly identical for all flags, a bit lower for French PS since 2004 (Spain+Seychelles 67 % vs 63 % for France), but this homogeneity may be artificial and exagerated by the data processing of the species composition)
2) The estimated % of SKJ were higher in the early period 1984-1994 (period dominated by natural logs): an average **75%;** they were lower since 1995, an average **64%** (period corresponding to the major development of FADs)

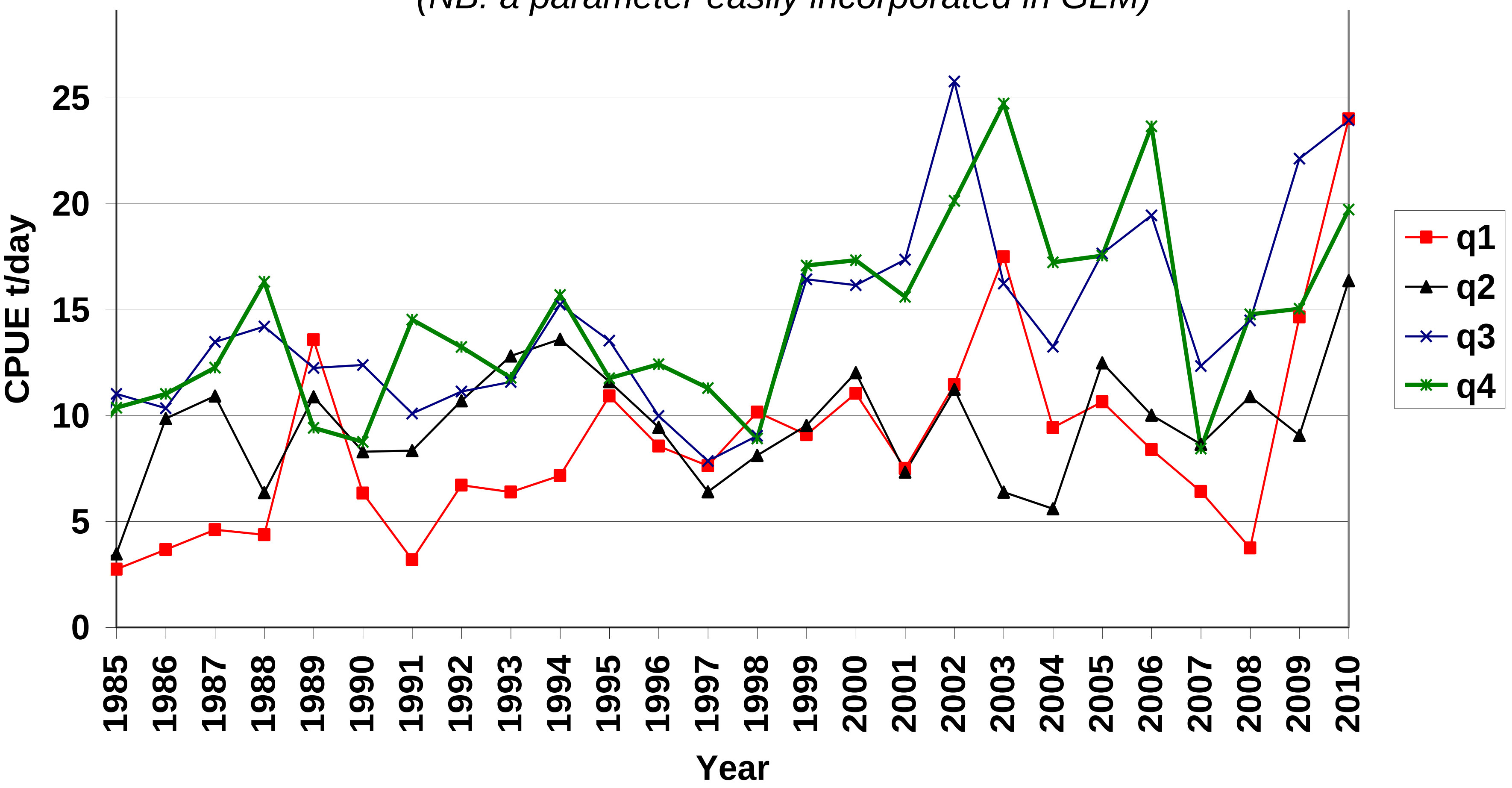
Figure 7: % of SKJ catches on FADs vs total SKJ catches of PS



1) A great majority of SKJ catches have been always taken by PS of log and FADs since 1984, average of 81%.
2) This % of SKJ from FADs has been always similar for all flags since 1987.
3) This % of SKJ from FADs has been increasing during recent years: reaching maxima over 90% during the last 3 years

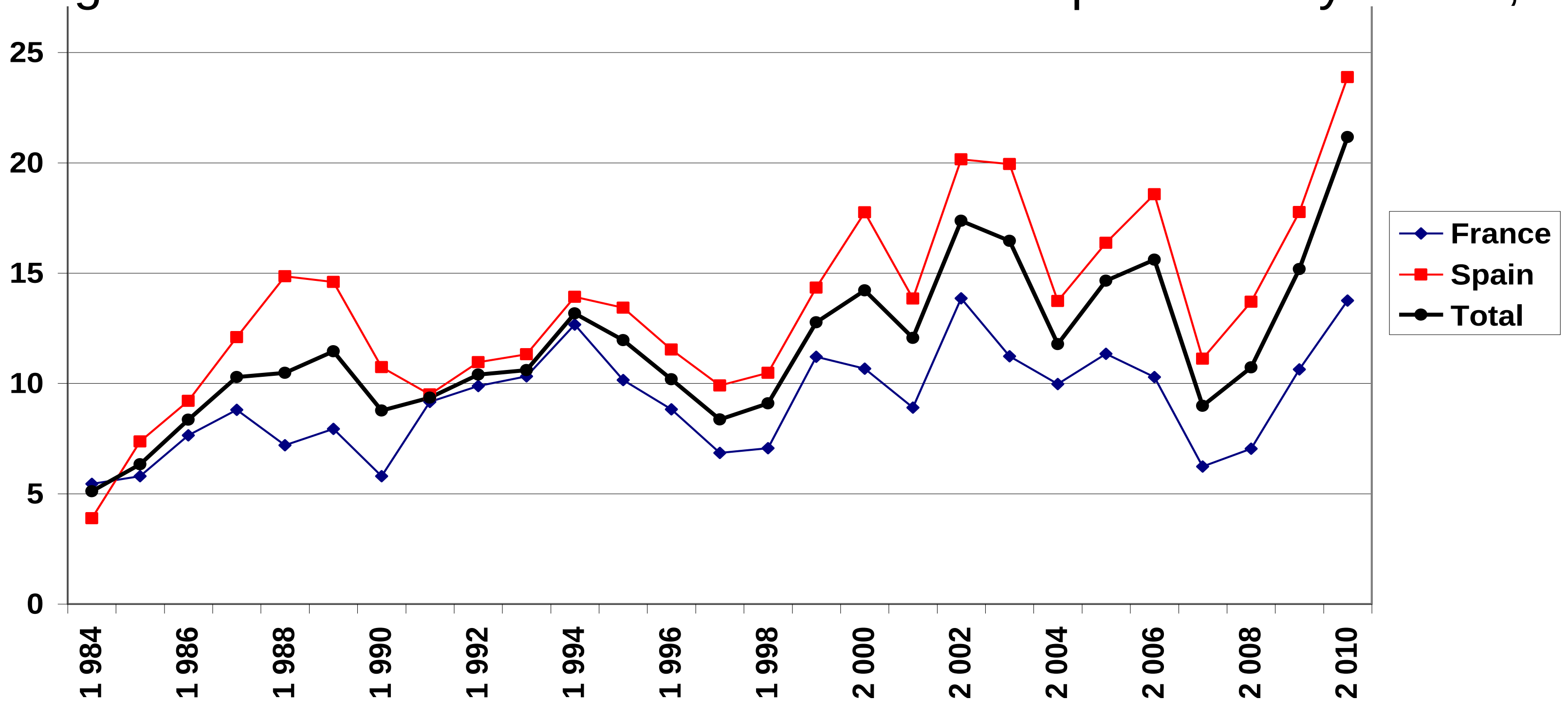
Figure 8: Seasonality: quarterly % SKJ in the total PS catches

(NB: a parameter easily incorporated in GLM)



1) A marked seasonality of SKJ CPUEs: lower CPUE of SKJ catches during the 1st quarter, and maximal during the 3rd and 4th quarters.
2) A trend to increased SKJ CPUEs since 1999, especially during the 3rd and 4th quarters
3) A great between years variance of this parameter

Figure 9: SKJ total CPUEs of PS: France & Spanish+Seychelles,

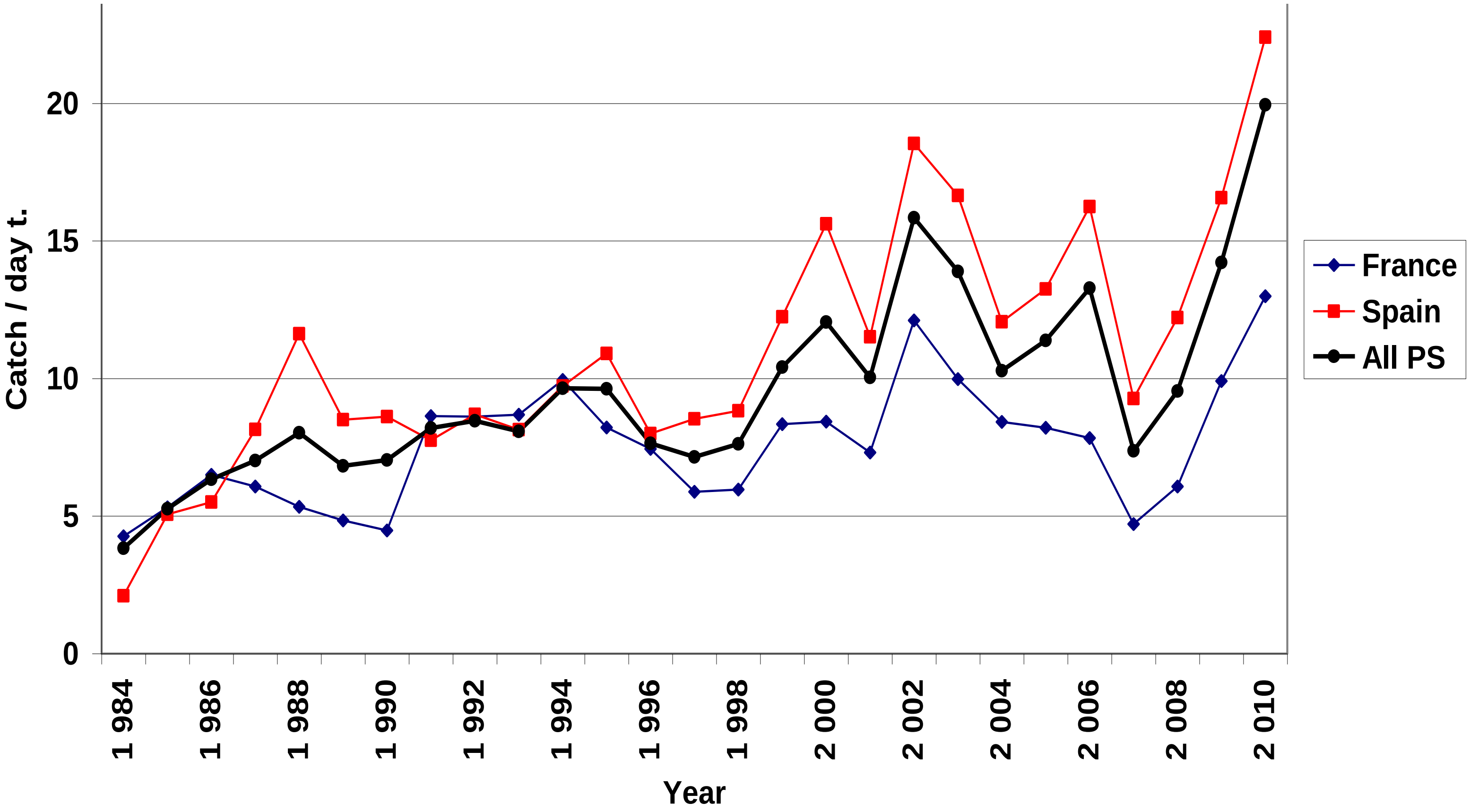


SKJ CPUEs (per fishing day) steadily increasing since 1984, probably due to increased efficiency and increased SKJ targeting (not to increasing SKJ biomass!)

1) Major CPUE increase for Spanish PS, especially since 1999
2) Relative stability of SKJ CPUEs for French PS since 1991
3) High SKJ CPUEs in 2009 and 2010, the period of maximal piracy (and reduced SKJ fished zones).

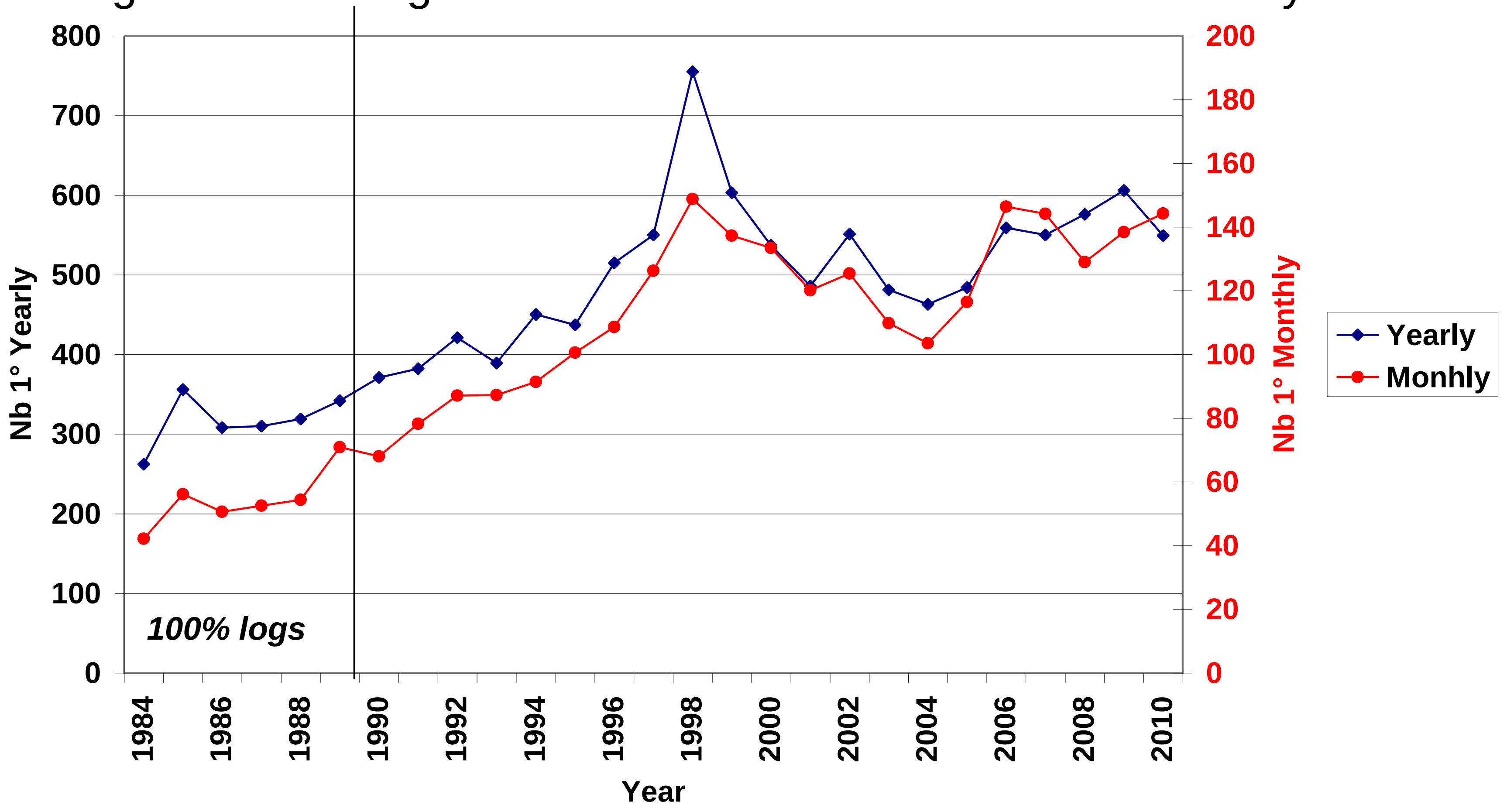
Comment: these observed trends of increasing SKJ PS CPUEs are not consistent with the increasing total catches: they are probably the consequence of increased PS efficiency and targeting (and FADs use), not of increased biomass of the SKJ stock

Figure 10: SKJ CPUEs of PS: France & Spanish+Seychelles, on FADs



1) SKJ CPUEs (per fishing day) on logs&FADs steadily increasing since 1984, probably due to increased efficiency and increased targeting
2) Major CPUE increase for Spanish PS, especially since 1999
3) Relatively stable SKJ CPUEs on FADs for French PS
4) High SKJ FAD CPUEs in 2009 and 2010, the period of maximal piracy.

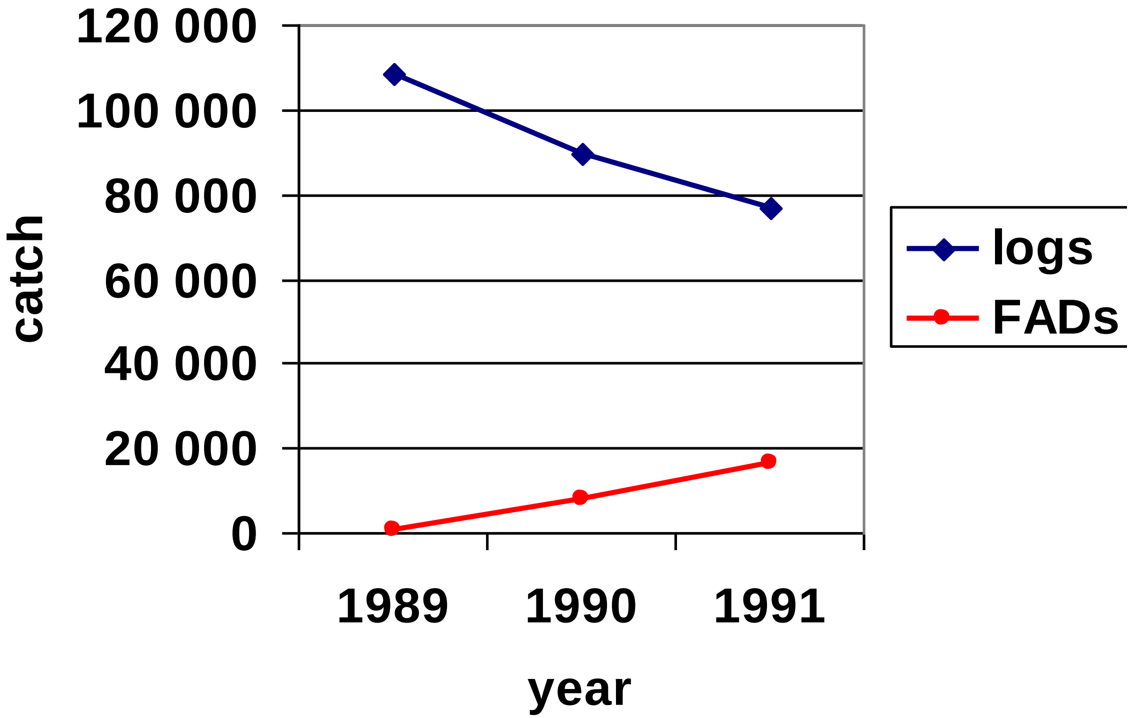
Figure 11: Changes in the total sizes of SKJ areas fished by EU PS



1) The yearly numbers of 1° square producing SKJ have been steadily increasing in the 1984-1996 period, and relatively stable since 1996
2) Trends are very similar at the monthly and yearly levels and numbers of 1° squares,

But the increase of surface fished beteween these 2 periods is larger at the monthly level (increase of **85%**), than at the yearly level (increase of **52%**)

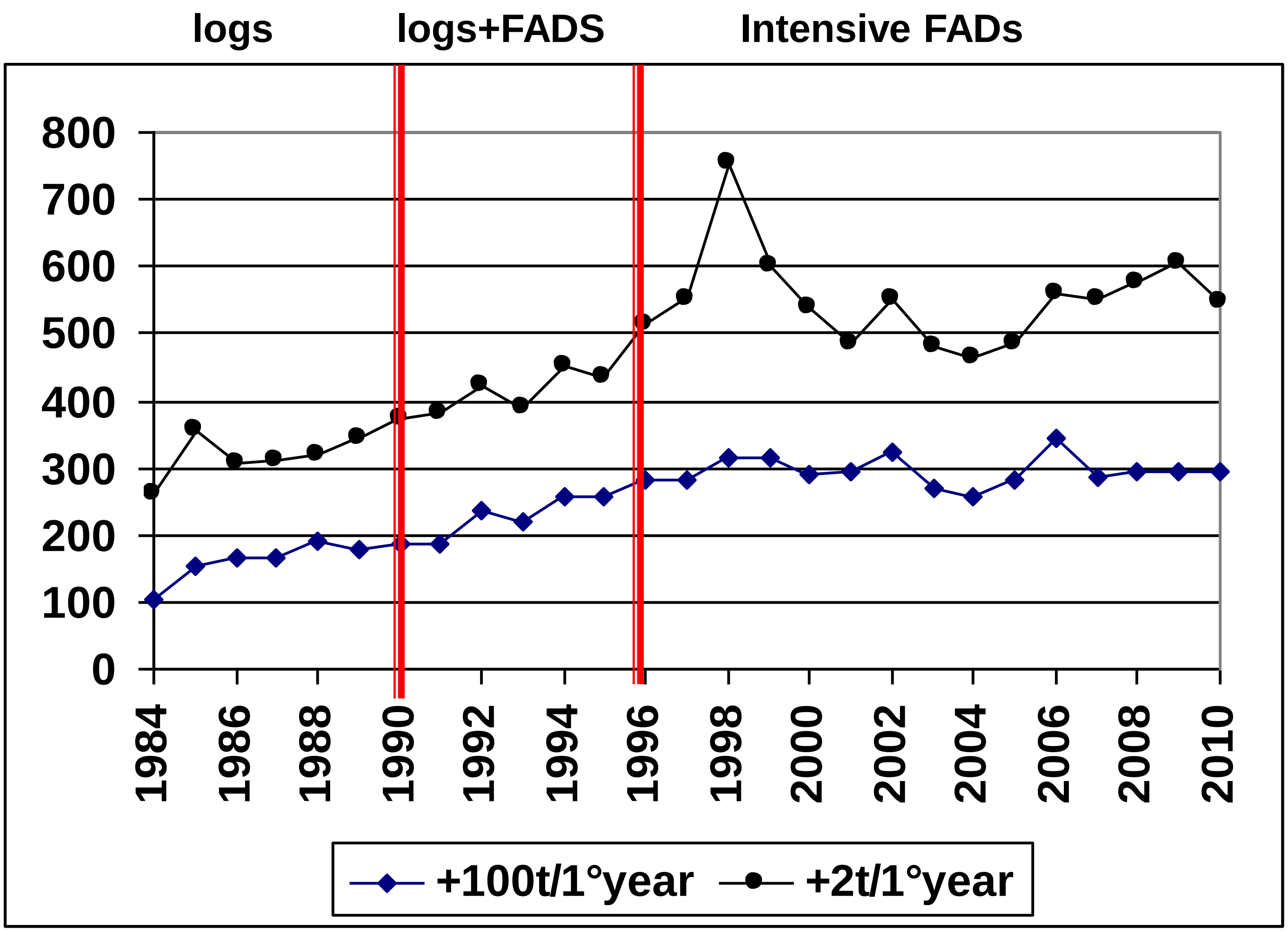
Figure 12: 1990-1995, birth of FADs:
development of FAD fishing & declining catches on natural logs



First FADs have been seeded in 1990, mainly by Spanish+Seychelles PS (Hallier Parajua 1992), but the type of floating objects (FAD or log) is not available for subsequent years

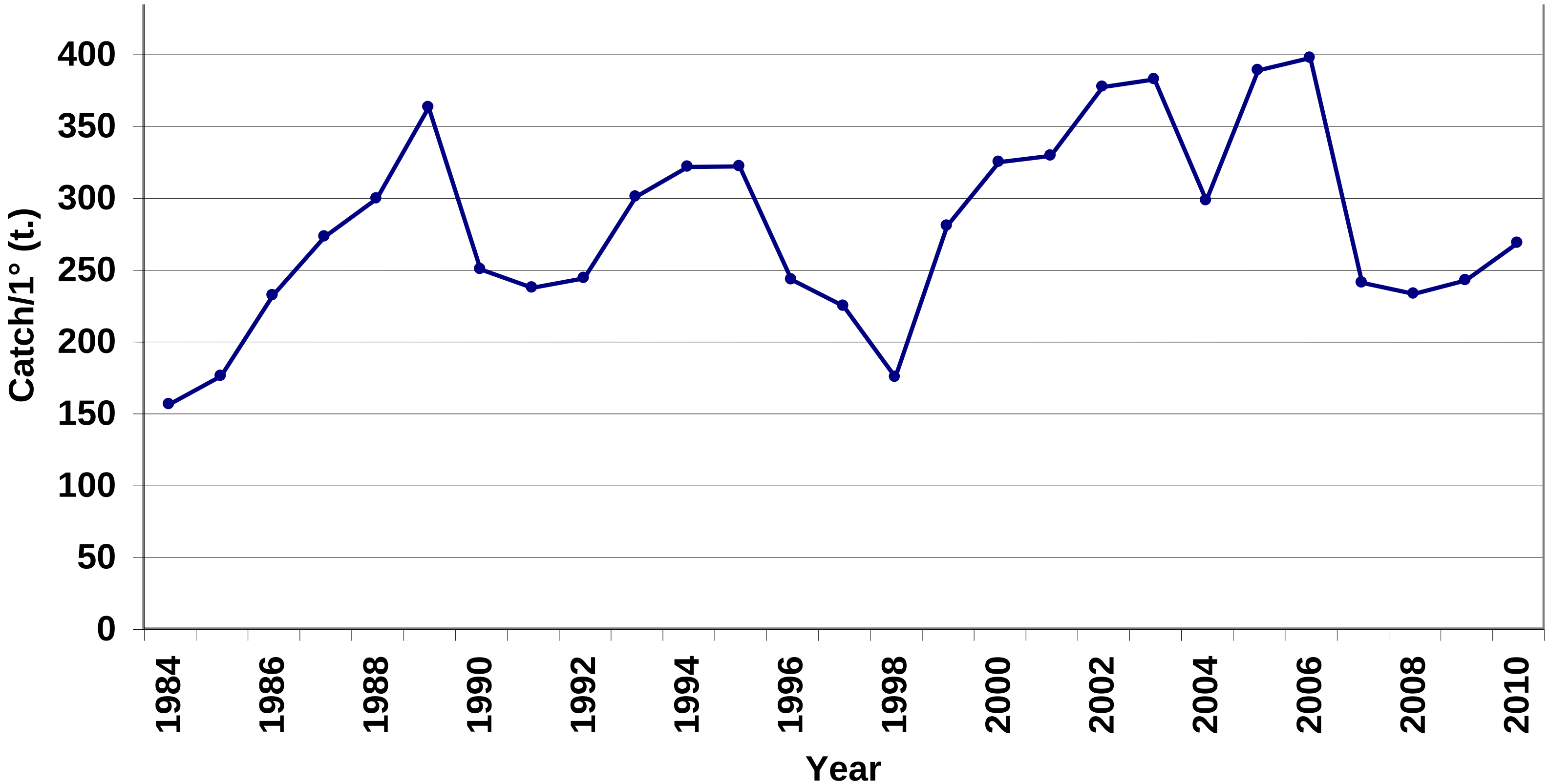
NB: natural logs were equipped by radio beacons and antenna allowing their localisation well before the seeding of FADs,

Figure 13: Average numbers of 1° squares with minimal SKJ catch (2 tons) & with significant catches (100 tons)



Same patterns and trends of this indicator for the 2 curves…

Figure 14: Average SKJ catches of PS by 1° squares fished yearly

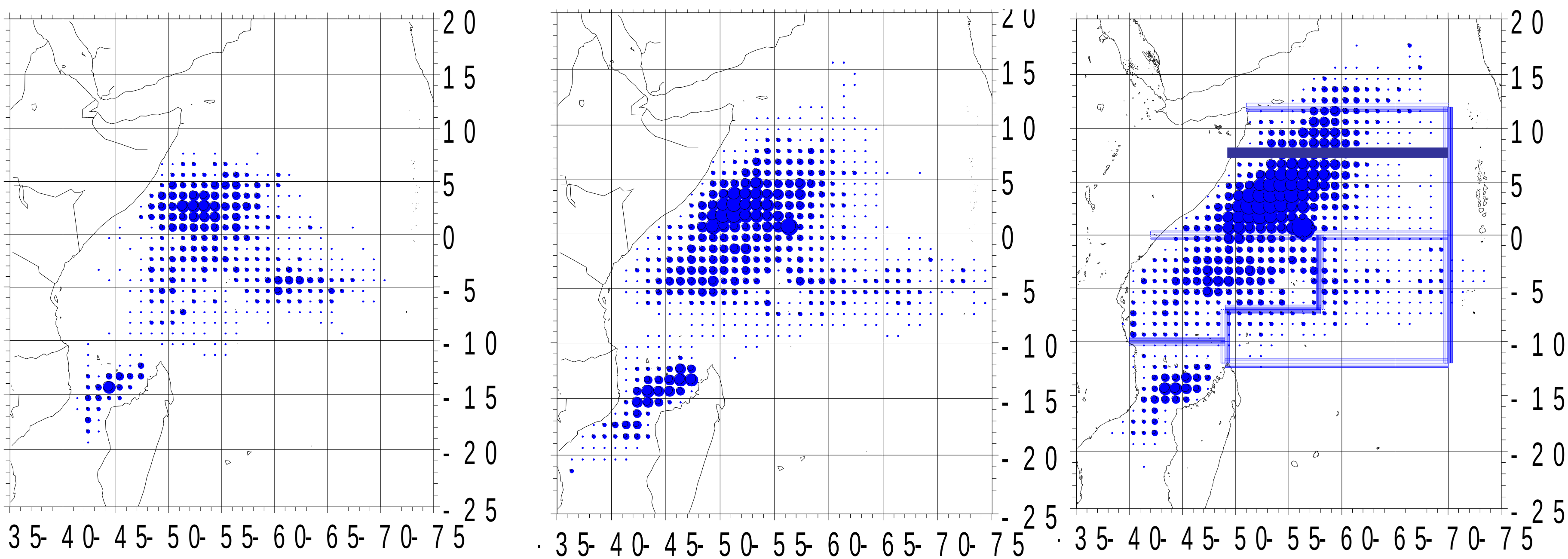


An indicator showing the average SKJ « productivity » by fished area

- ➢Showing significant fluctuations between 175 t. & 400 t. of SKJ caught yearly by 1° square
- ➢Higher levels during the 1999-2006 period (347t.) compared to the 1986-1998 period (268t),
- ➢Lower level during the 2007-2010 period: only 246 t./1° square

Figure 15: Basic SKJ maps to keep in mind
Mid 90ies: period of major increase of FADs seeding and numbers,

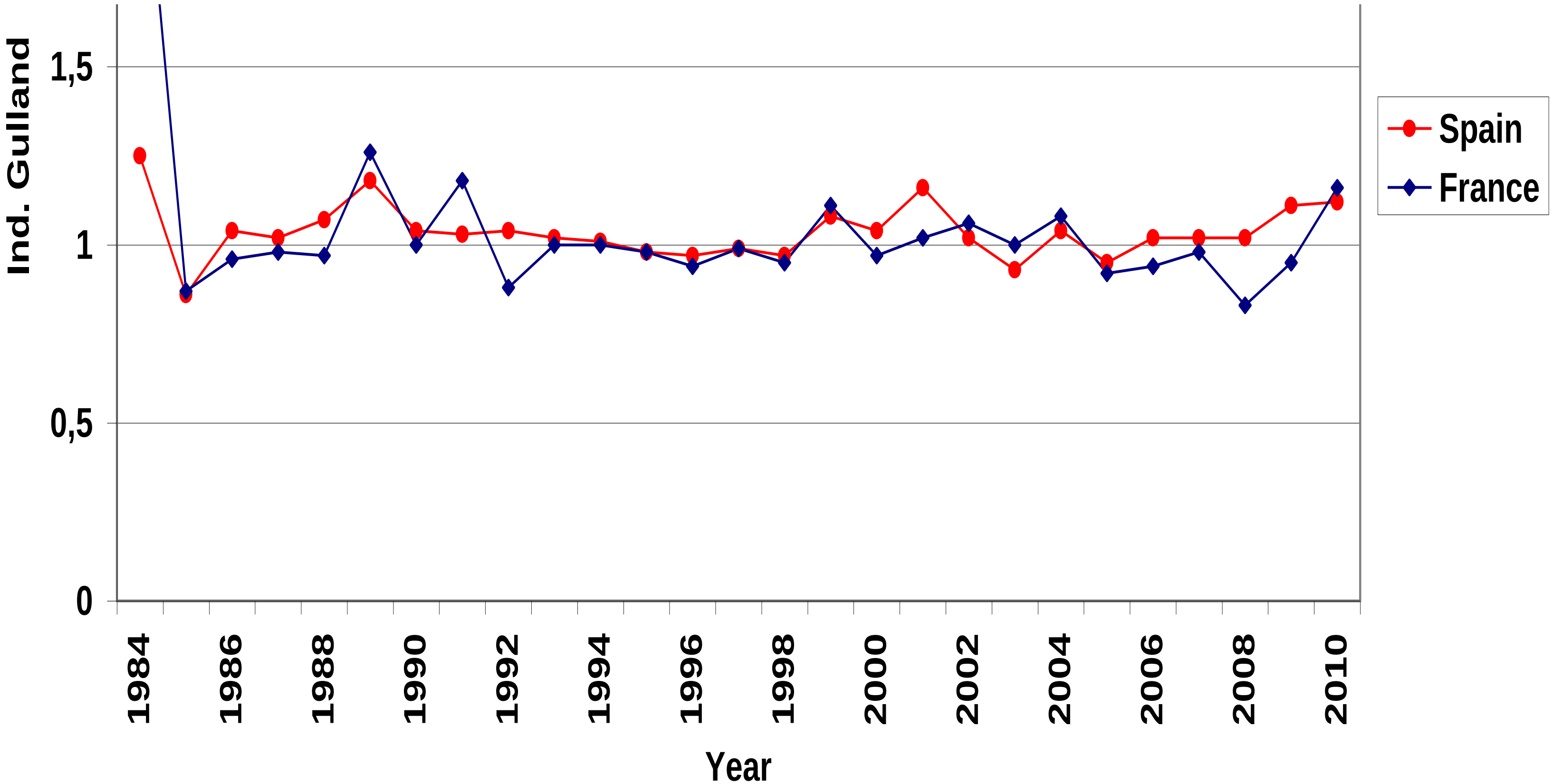
- ➢ Fishing of SKJ on natural logs has been commonly used in the Western Indian Ocean by PS since the begginning of the PS fishery in 1983.
- ➢ Artificial FADs seeded by PS have been widely used since 1990 by Spanish+Seychelles PS and since 1992 by French PS, increasing targeting on SKJ.
- ➢ Fishing zones of natural logs and FAD are different, mainly towards NE areas: FADs being seeded (and drifting) in wider areas than logs, & most often targeting SKJ.



1983-1989 **1990-1999** **2000-2010**

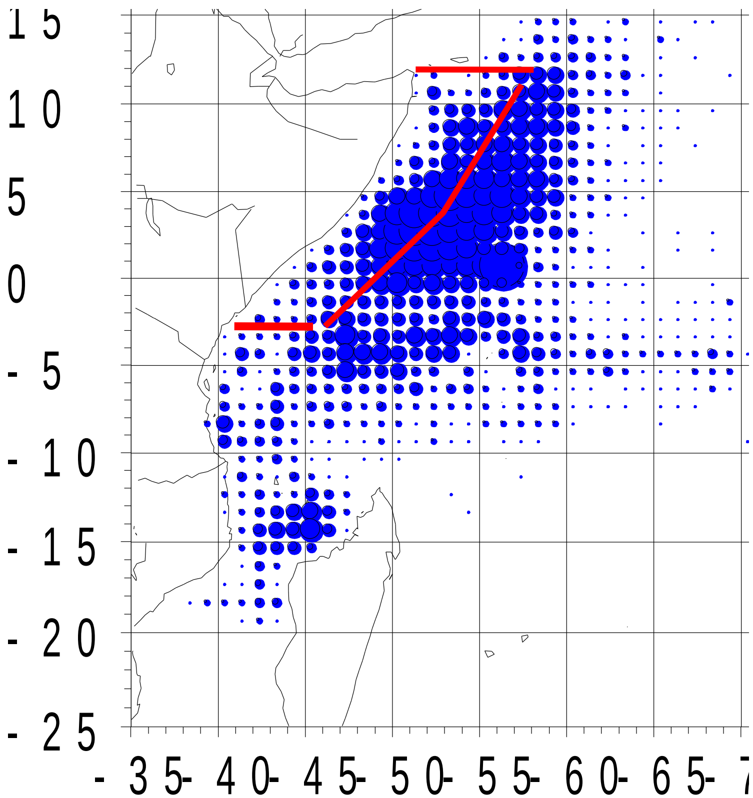
SKJ catches on log/FADs /EU PS

Figure 16: Changes in the SKJ concentration patterns: SKJ Gulland's Index

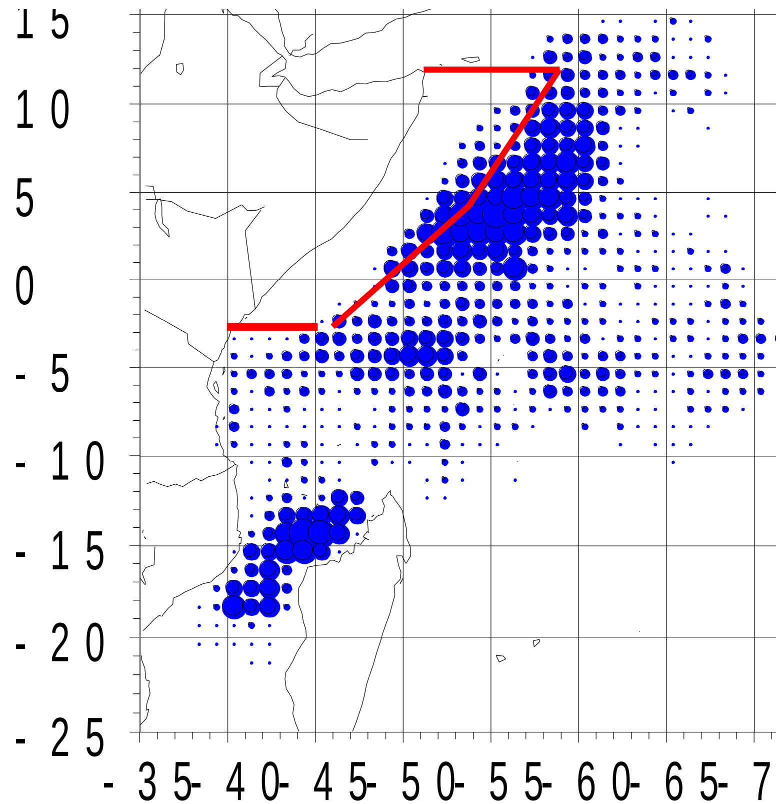


1) SKJ Gulland's index of PS are close to 1 (no real concentration on SKJ high biomass)
2) They are at similar levels for French and Spanish+Seychelles PS: similar fleet behavior on SKJ large biomass
3) Lower Gulland's index for French PS during the 2005-2009 period, but not in 2010!

Figure 17a: Visible Negative effects due to Somalian piracy: loss of SKJ fishing strata?



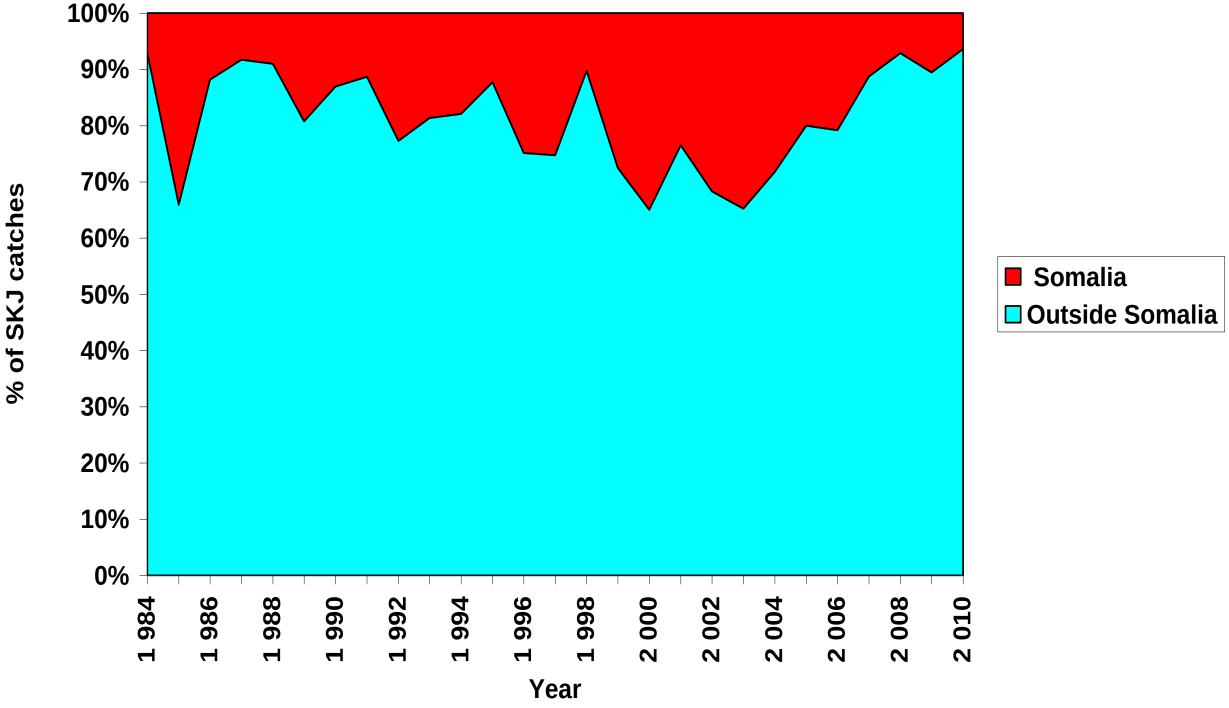
SKJ catches /PS 2000-2006

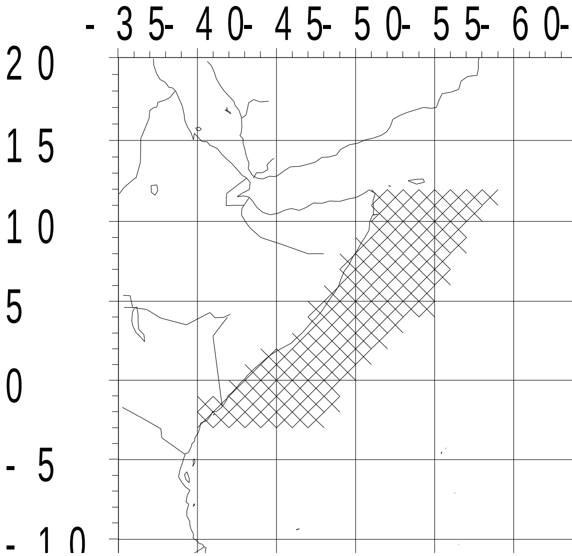


SKJ catches /PS 2008-2010

-Fishing zones 300 miles of Somalia were actively fished for SKJ by PS until 2006
- These large coastal catches have been wideely reduced during recent years
- During recent years 2008-2010: there was no alternate SKJ fishing zone found and exploited by PS

Figure 17b: % of PS SKJ catches off Somalian 300 miles….. piracy waters

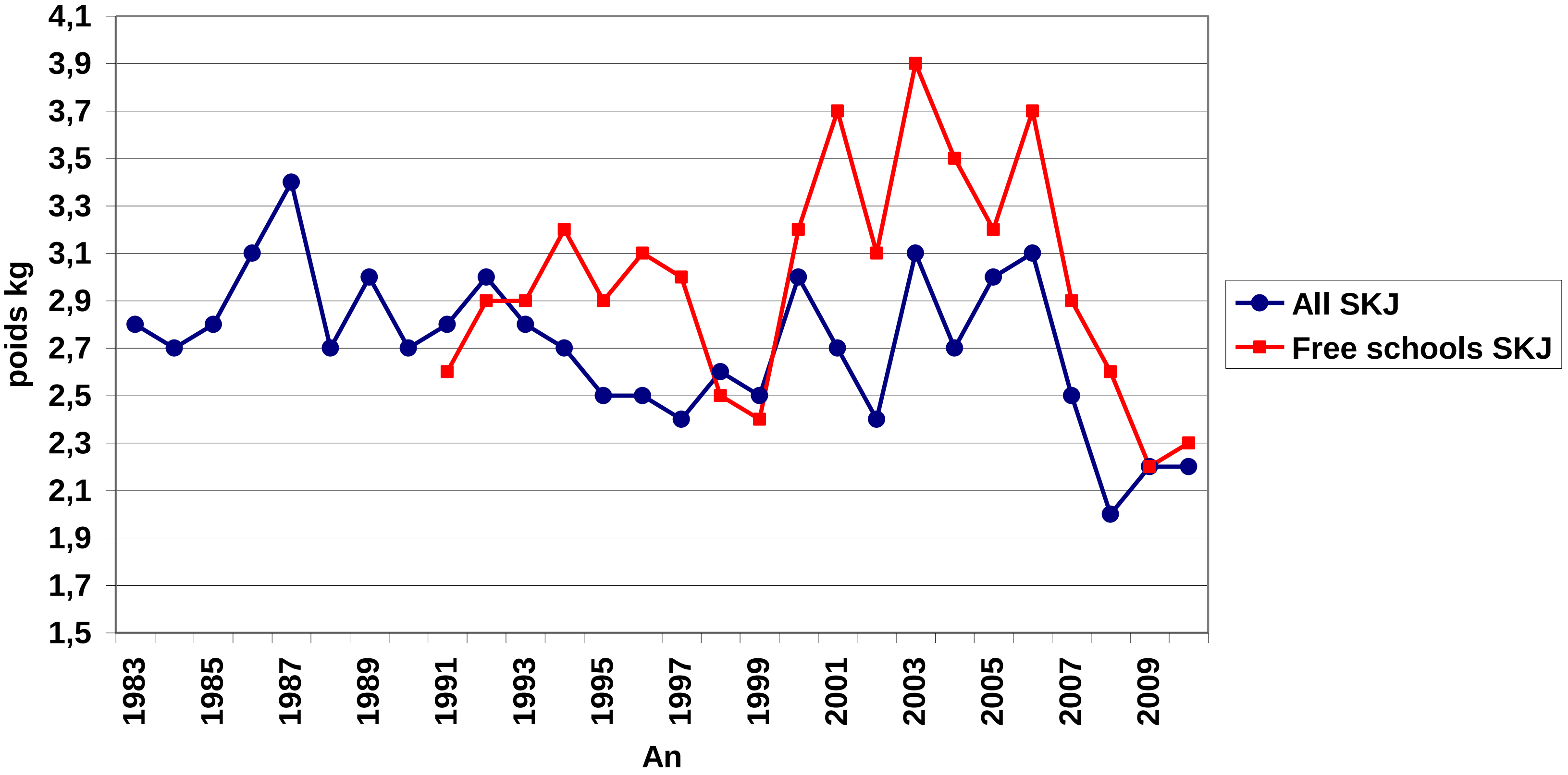




Somalian waters:
Main piracy area, reaching 250-300 miles offshore

- 28% of SKJ catches taken in these Somalian waters during the 2000-2006 period
- Only 9% of SKJ catches taken in this area during the 2007-2010 period

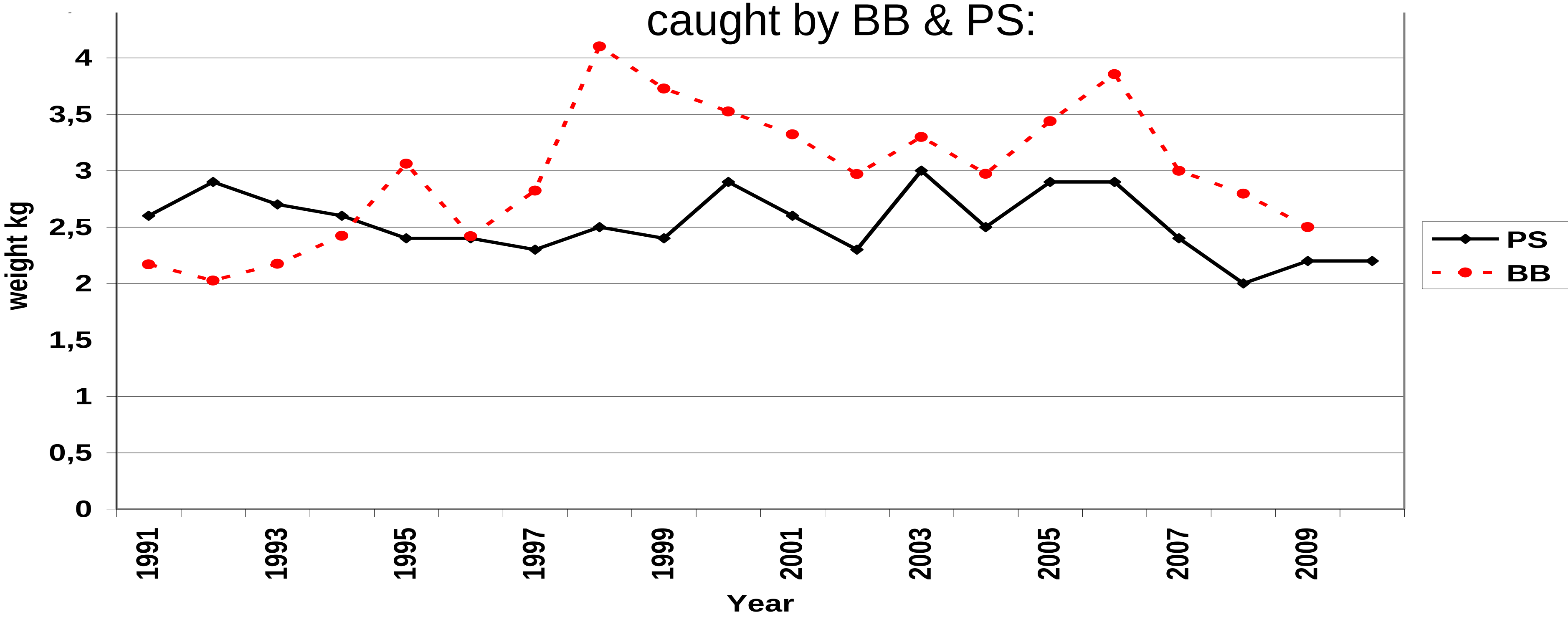
Figure 18a: SKJ average weight caught by all the EU PS fisheries, total & on free schools



➢ Quite stable and high average SKJ weights taken by the combined PS fisheries during the 1985-2010 period: average = 2.9 kg

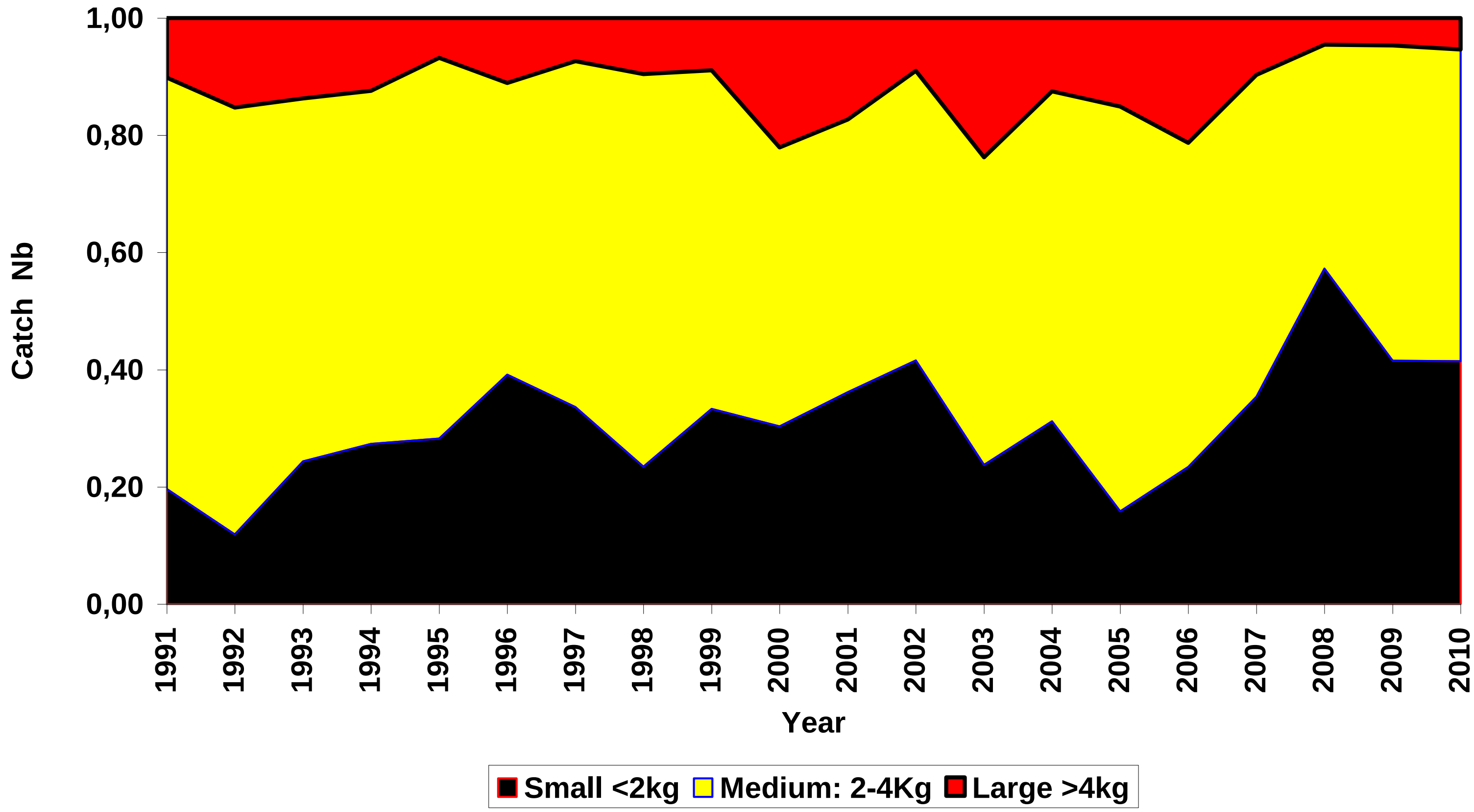
➢ Moderate decline of average weight caught in recent years 2008-2010: average = 2.8 kg. Average weights already observed dururing the early nineties, higher than the average weights before the PS

Figure 18a: Changes in raw (non standardized) SKJ average weight caught by BB & PS:



1) Average SKJ weight caught by PS were high (2.6kg) (compared to the Atlantic: 2.0 kg) & quite stable untill 2006
2) Lowest average SKJ weight caught by PS have been observed during the last 3 years: 2008-2010 (2.1 kg) : why?
3) Average weight caught by BB, mainly in Maldives, have been much larger and stable during the 1996-2006 period, & also declining during recent years since 2007; *low levels in the early years 1991-1996 may be questionable?*

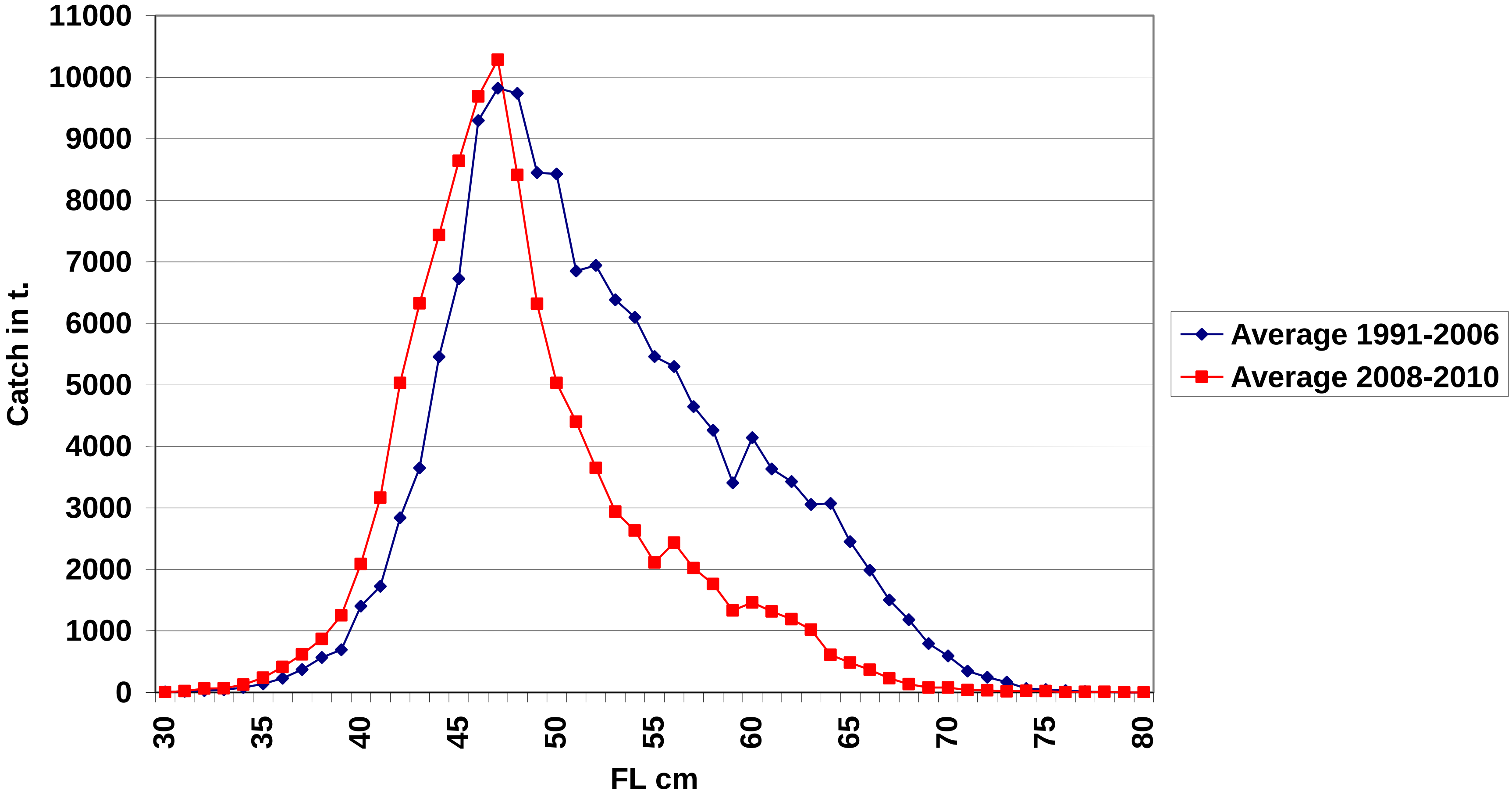
Figure 18c: Why such reduced average SKJ weights caught since 2008?



Catches of SKJ by size categories, small/medium/large, are showing during the last 3 years:

1) An increasing % of small SKJ <2kg,
2) A decreasing % of medium and large SKJ >2kg
3) This change in the CAS is the main cause of decreasing average weight
4) It could be due: (1) to increasing Exploitation rates of the stock (less old fishes in the pop.), (2) to increased recruitments, (3) to changes in fishing strata or to other parameters

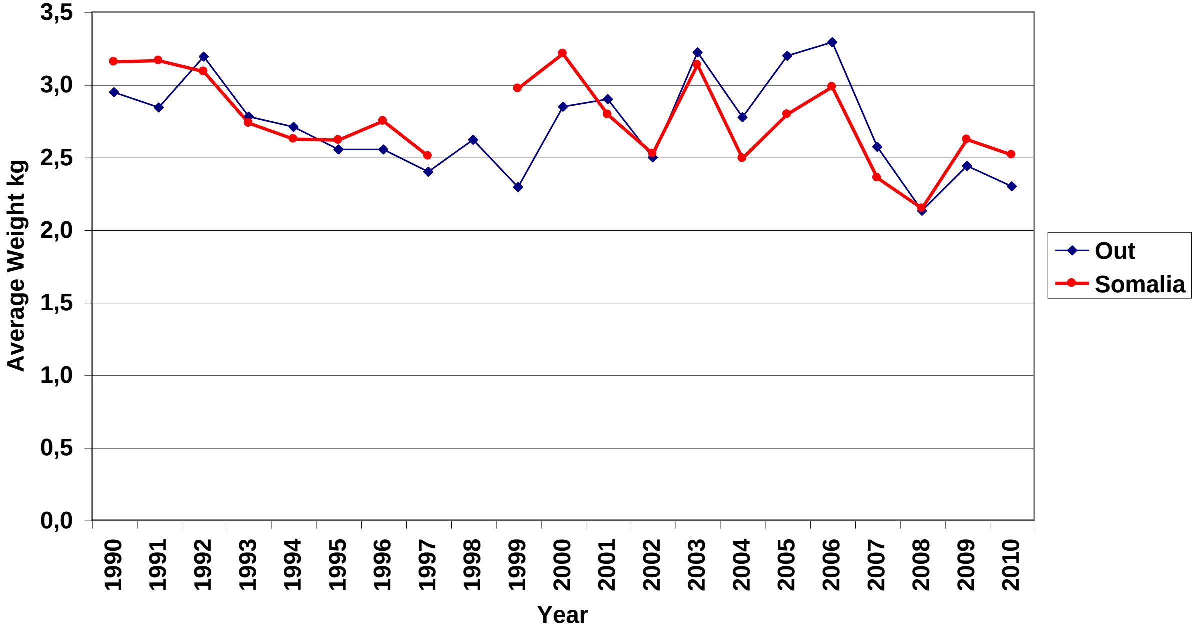
Figure 18d: Changes in SKJ total average PS CAS

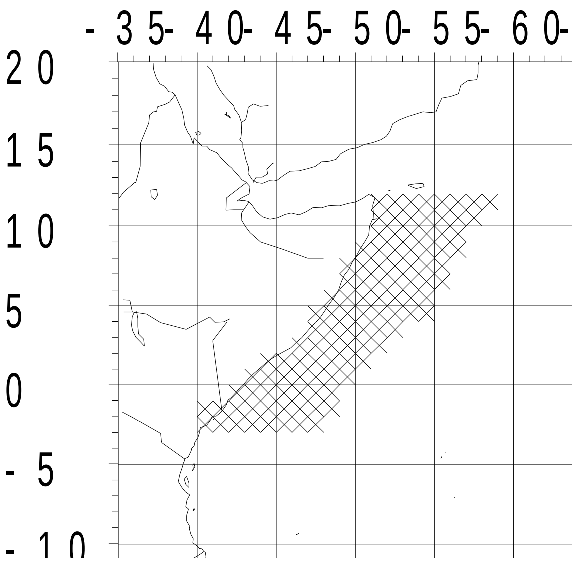


Average SKJ catch at size during the pre and post 2007 period shows the major declines observed in the catch of large SKJ and the increase in the catches of small SKJ, probably indicative of an adult biomass showing a significant decline.

NB: a 2 kg SKJ measures 47 cm, a 4 kg SKJ measures 57 cm.

Figure 18e: Average SKJ weight in the Offshore Somalian area





Somalian waters: Main piracy area, reaching at least 250-300 miles offshore

1) The yearly average weight of SKJ taken by PS in the Somalian area can be estimated from the original samples by 1° squares
2) The yearly average of SKJ taken by PS, In&Out Somalia area, during recent years are showing very similar levels & trends……
3) Recent decline of SKJ of average weights observed in the PS fisheries are not due to a Somalia area effect.
4) They are probably the consequence of increasing and high exploitation rates of the SKJ stock in the IO: full exploitation?

Figure 18f: Catches of small, medium and large SKJ, before (1991-2006) and during (2008-2010) the piracy period

Small SKJ | **Medium SKJ** | **Big SKJ**

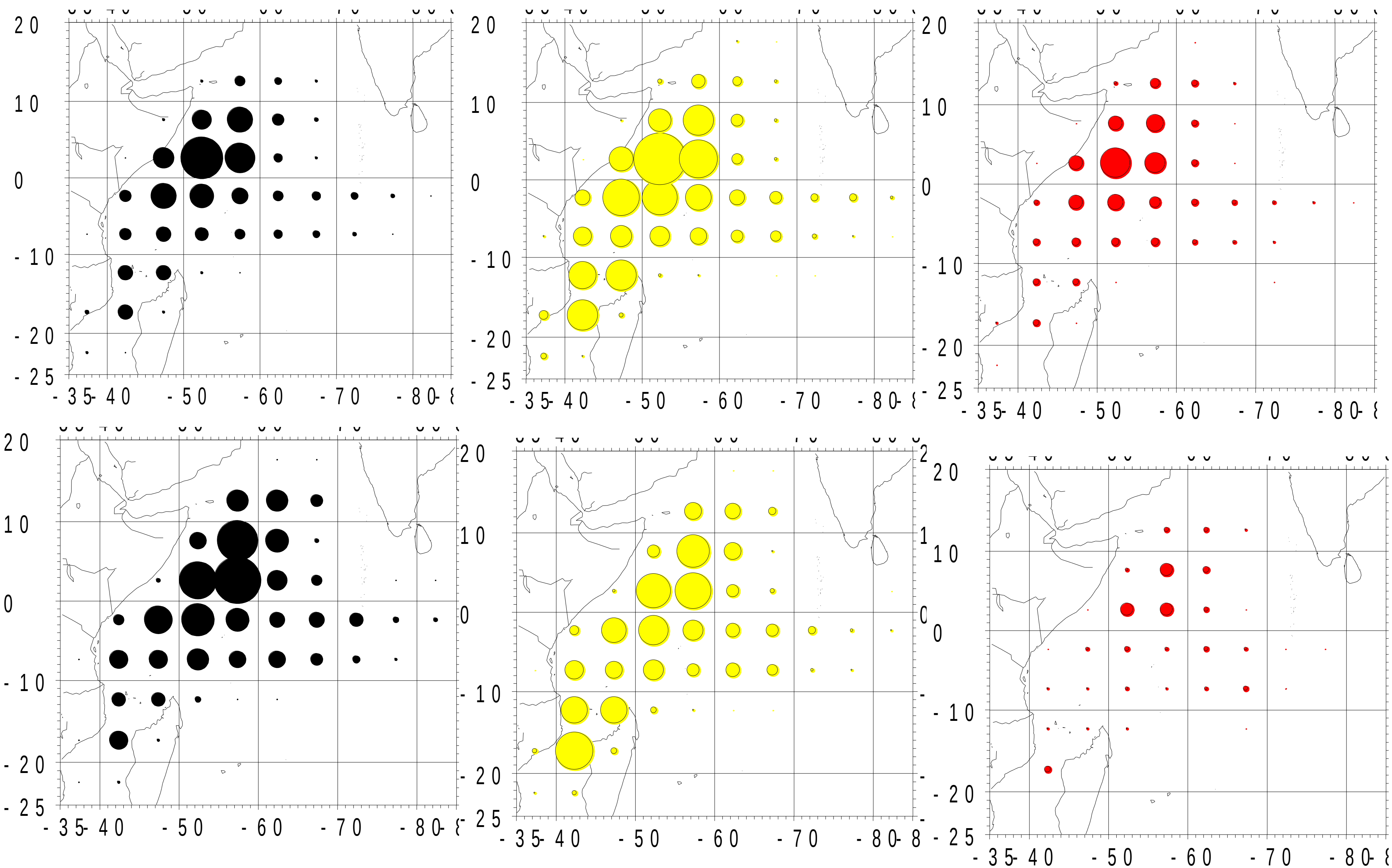
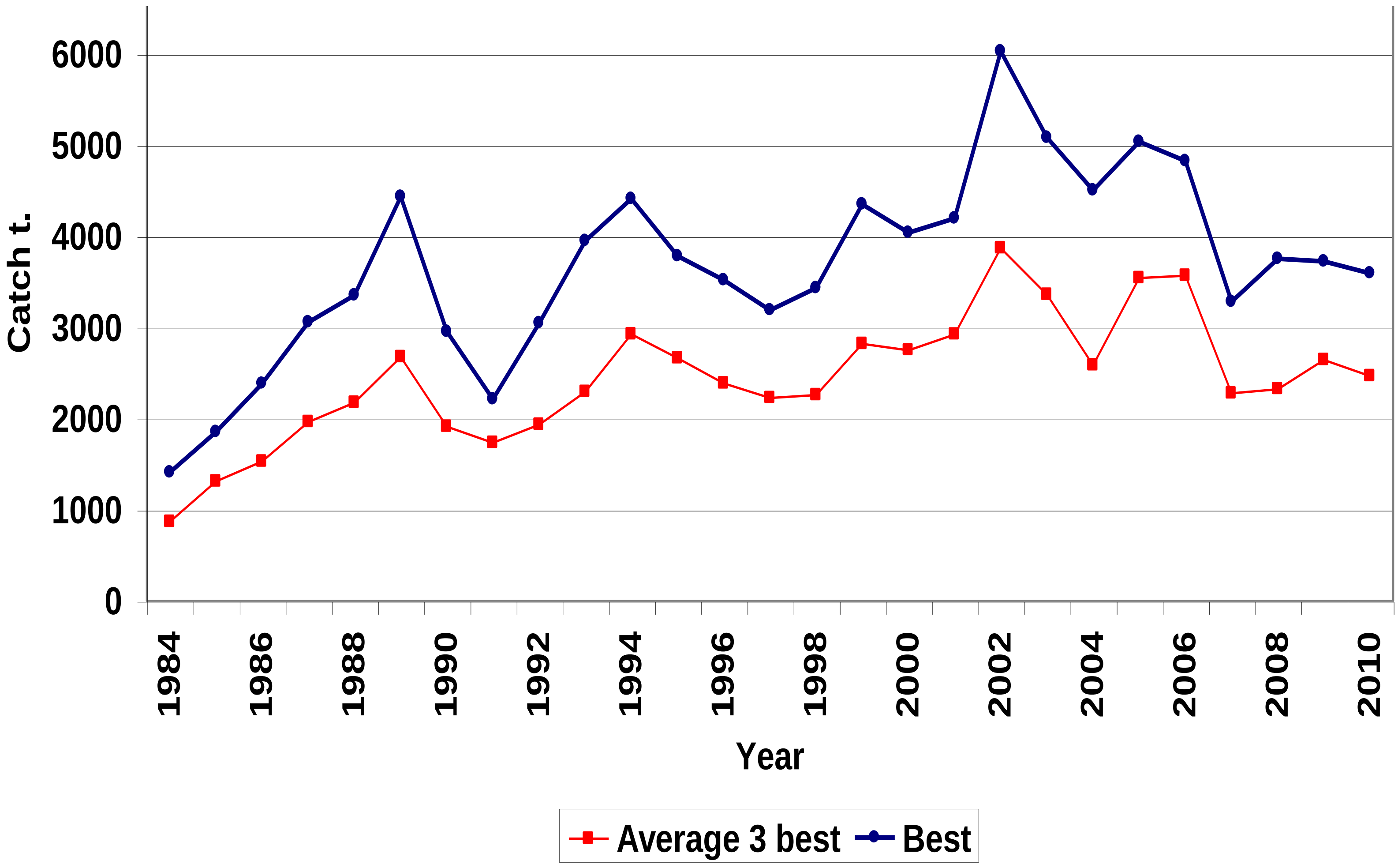
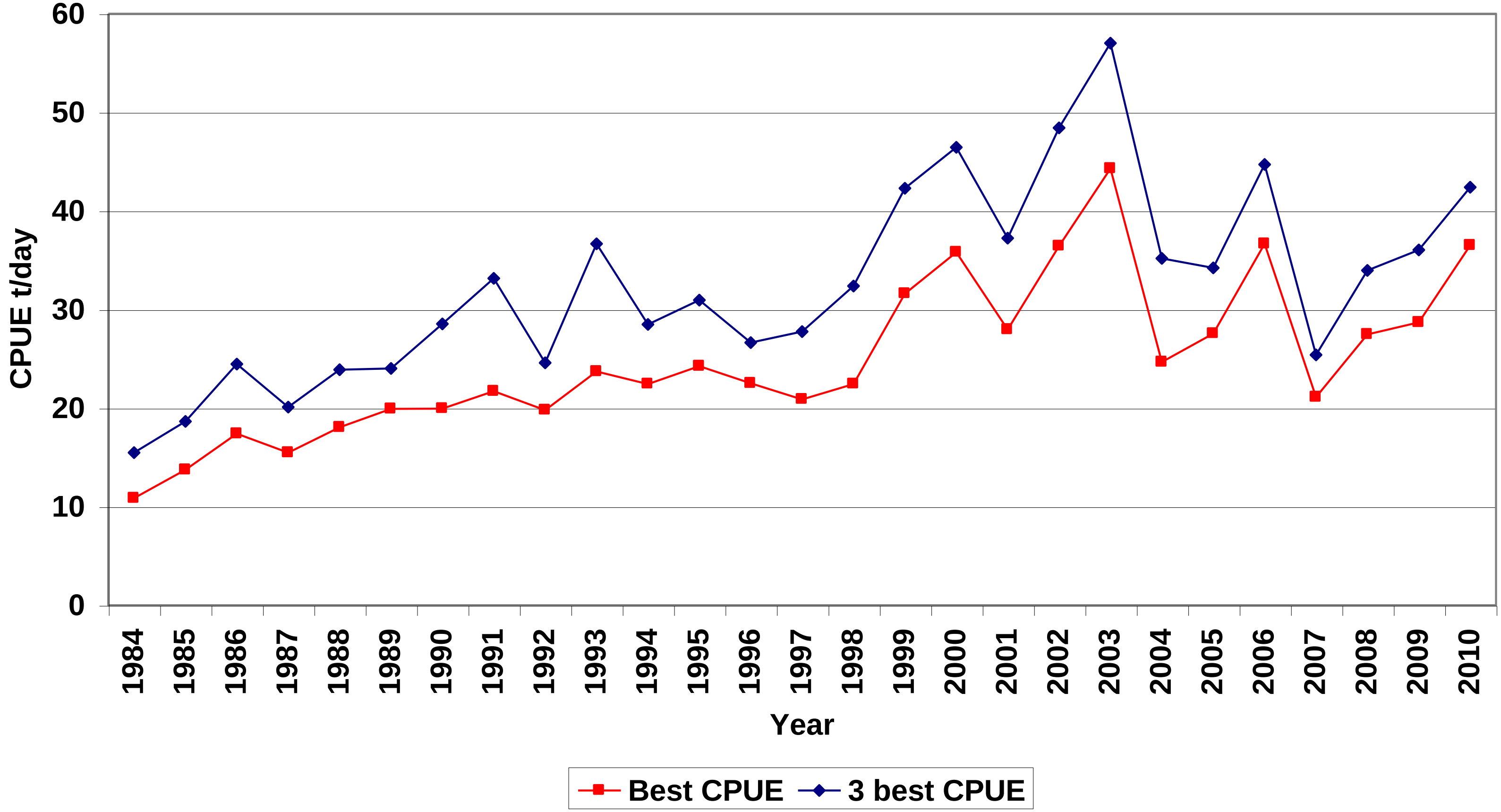


Figure 19a: monthly catches of SKJ in the 3 best & best 5° square: yearly average



- Steadily increasing SKJ catches during the 1984-2002 period
- Maximum SKJ catches by 5°squares observed during the 2002-2006 period: average 5100t.
- Lower levels of Max SKJ catches since 2007: 3600t.

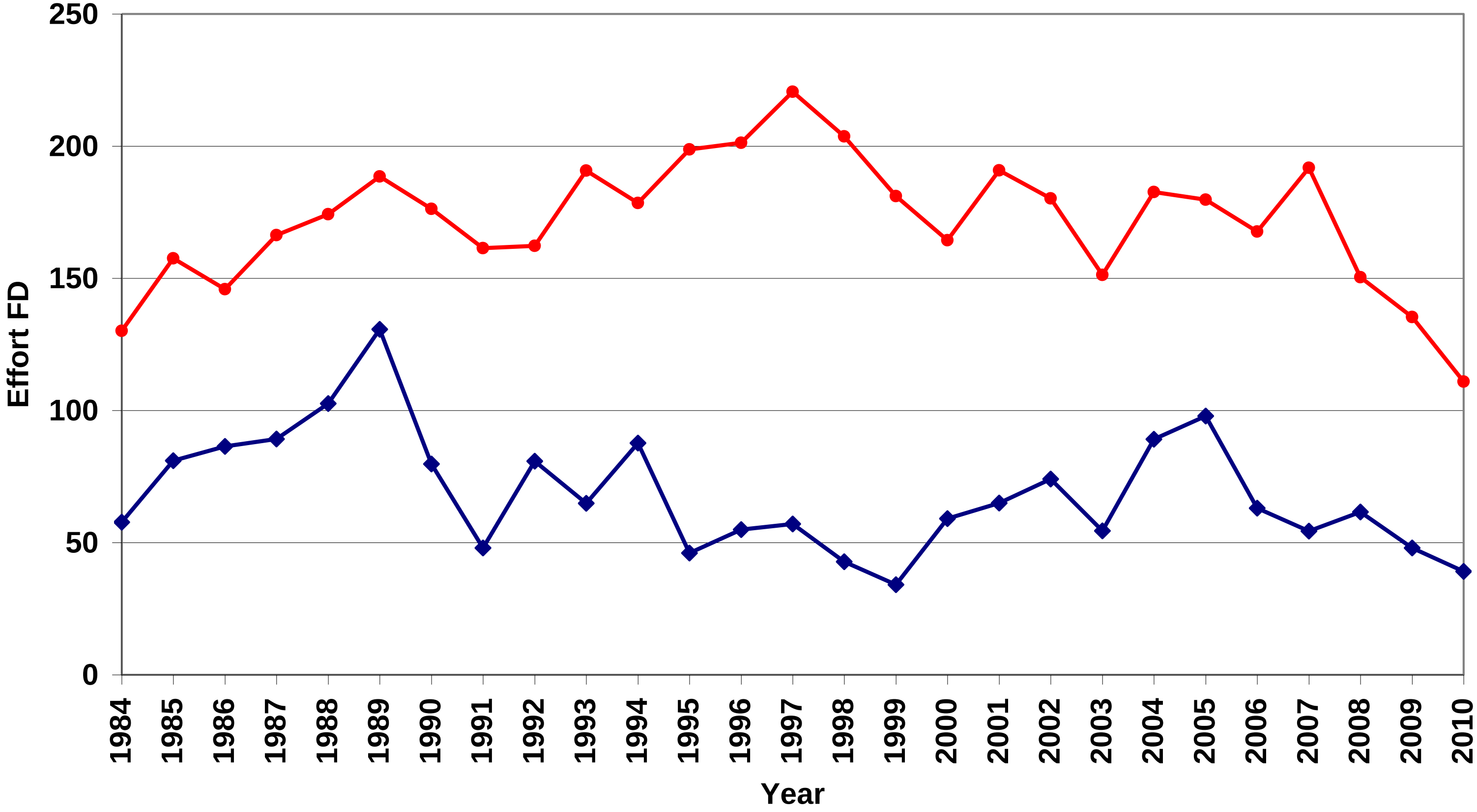
Figure 19b: Best monthly CPUE of SKJ (tons/fishing day) by 5°: yearly average



-Maximal SKJ CPUE showing similar trends

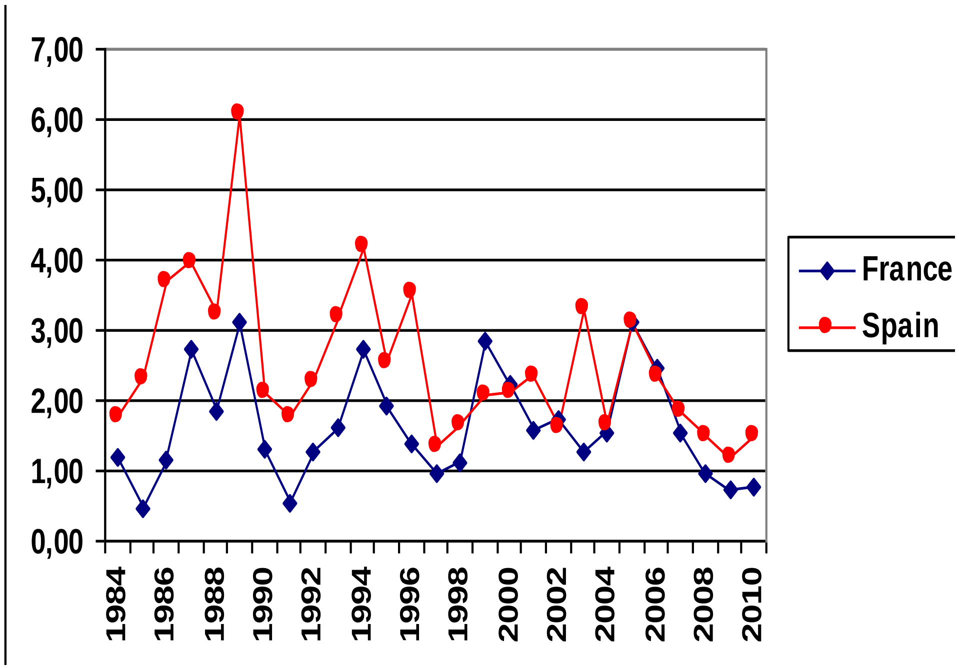
-But best CPUEs during recent years observed at relatively high levels, typically post 1998 levels

Figure 19c: Average fishing efforts exerted in the 3 best monthly CPUE of SKJ by 5° (yearly average)

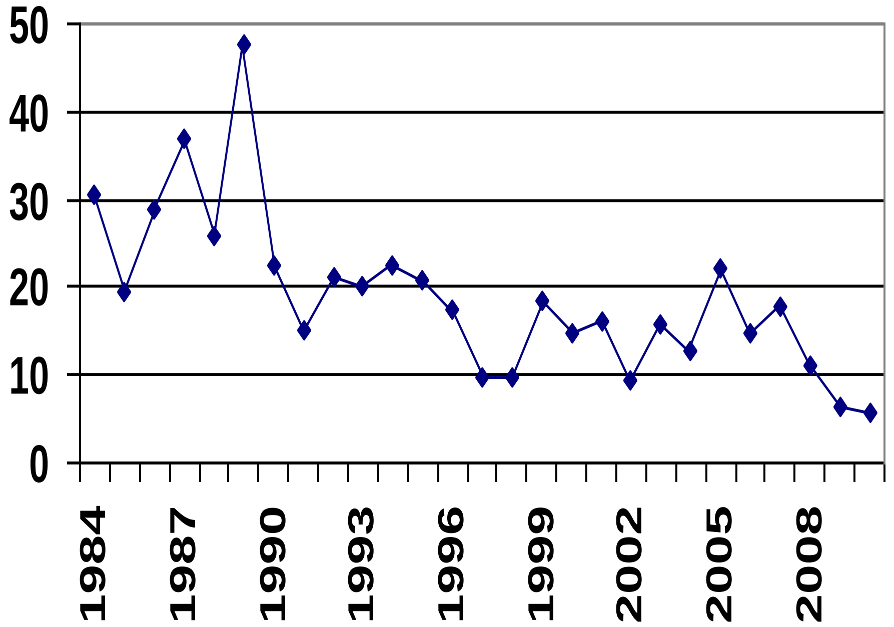


- Stable trend of nominal fishing efforts in the strata of best SKJ Catches,
- Moderate decline of nominal fishing efforts in the strata of best SKJ CPUEs,
- Both curves are much more stable than the total fishing efforts
- Much higher levels of fishing efforts in the strata of best catches

Figure 19d: SKJ taken on free schools by EU PS:



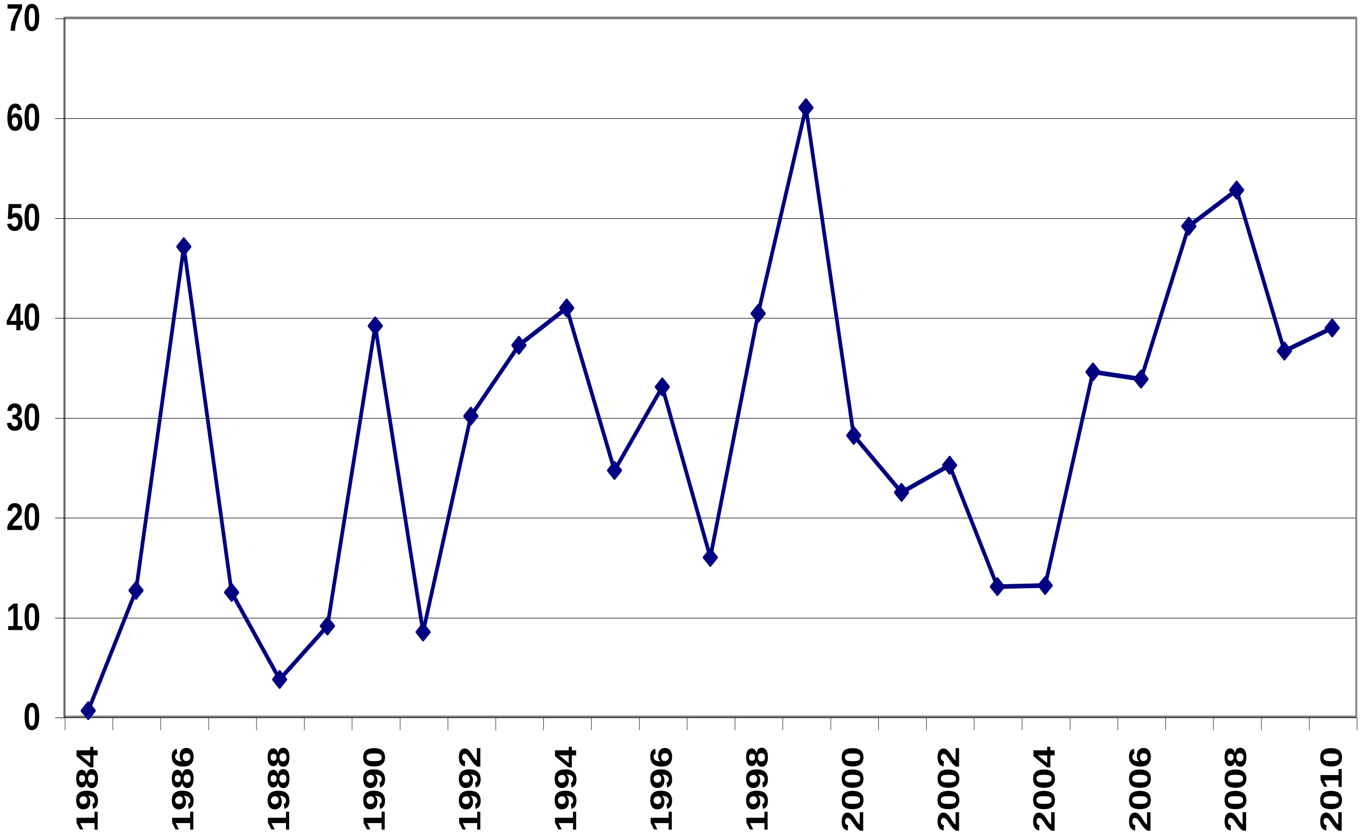
Free schools SKJ CPUEs



% of SKJ taken by free schools sets

- A steady decline of free schools SKJ CPUEs, especially for Spain; 2009 and 2010 at their lowest levels
- A steady decline of the % of SKJ caugh /FAD vs total SKJ catches by PS; 2009 and 2010 at their lowest levels
- The causes of these declines have not been identified: they should be investigated

Figure 18 e free schools SKJ: % of SKJ catches taken in the Mozambic channel (average 1985-2010: 29%)

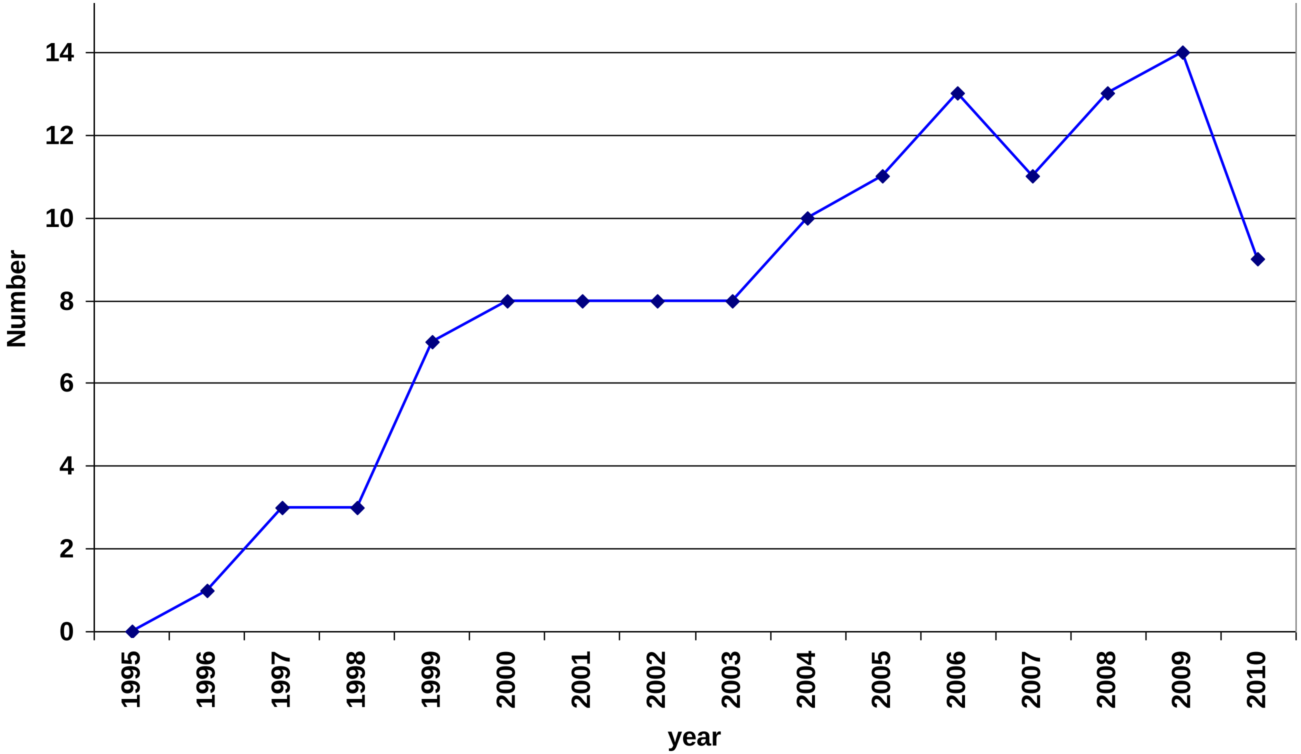


-Mozambic Channel: a small area producing only 11% of total PS catches
-And also 11% of FAD catches taken on FADS
-But an important area for free schools SKJ: 29% of total free school SKJ catches

Part 2: Changes in the PS SKJ fishery that are important in the fishery data, but visible only in the fine scale data

1) Changes in the fishing efforts by supply vessels, figure 20 a & b
2) Changes in the average distances travelled by PS per fishing day and CPUEs/nautical miles, figure 21.
3) SKJ CPUEs by 1000 Nautical miles, medium size PS, figure 22.
4) Changes in the age of PS: reduced efficiency, figure 23.
5) Changes in sizes of fishing vessels & differential targeting of SKJ for EU PS, figure 24 a,b & c.
6) Changes in the numbers of FAD sets, figure 25 a & b.
7) Changes in the SKJ average catches per FAD set, figure 26.

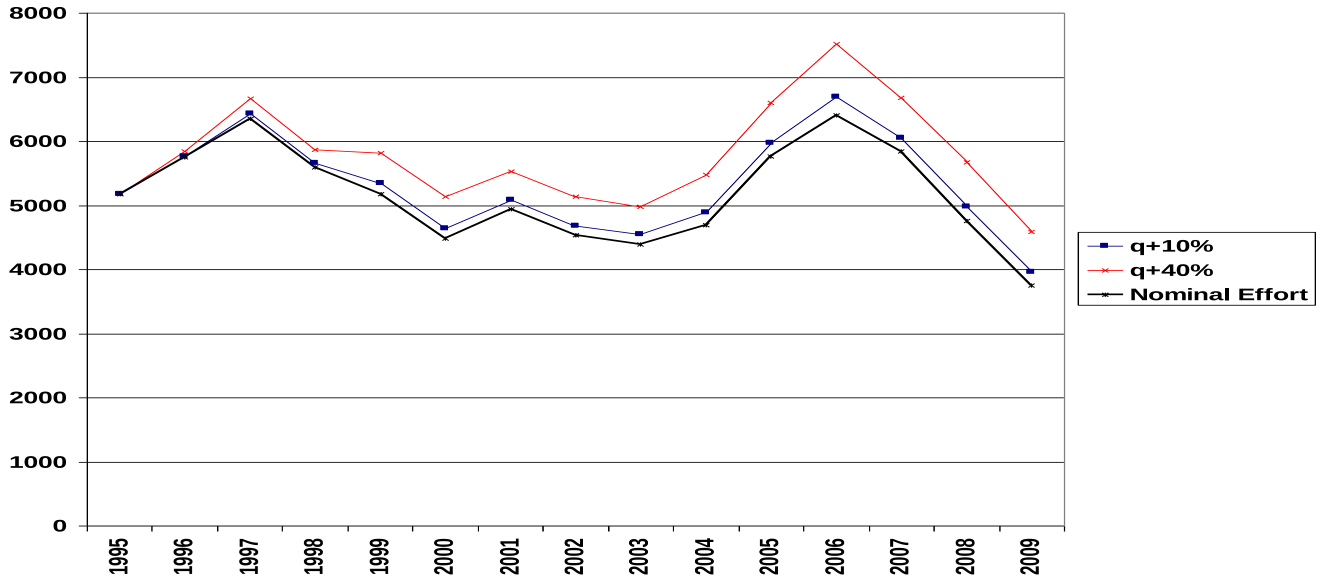
Figure 20 a: Numbers of supply vessels active in the Indian Ocean to support Spanish+Seychelles PS



1) Supply vessels since 1996: most of them targeting FADs & SKJ, 1 or 2 supplies anchored on sea mount
2) Increasing numbers of supplies during the 1996-2006 period
3) Declining number in 2010: *due to piracy effect?*

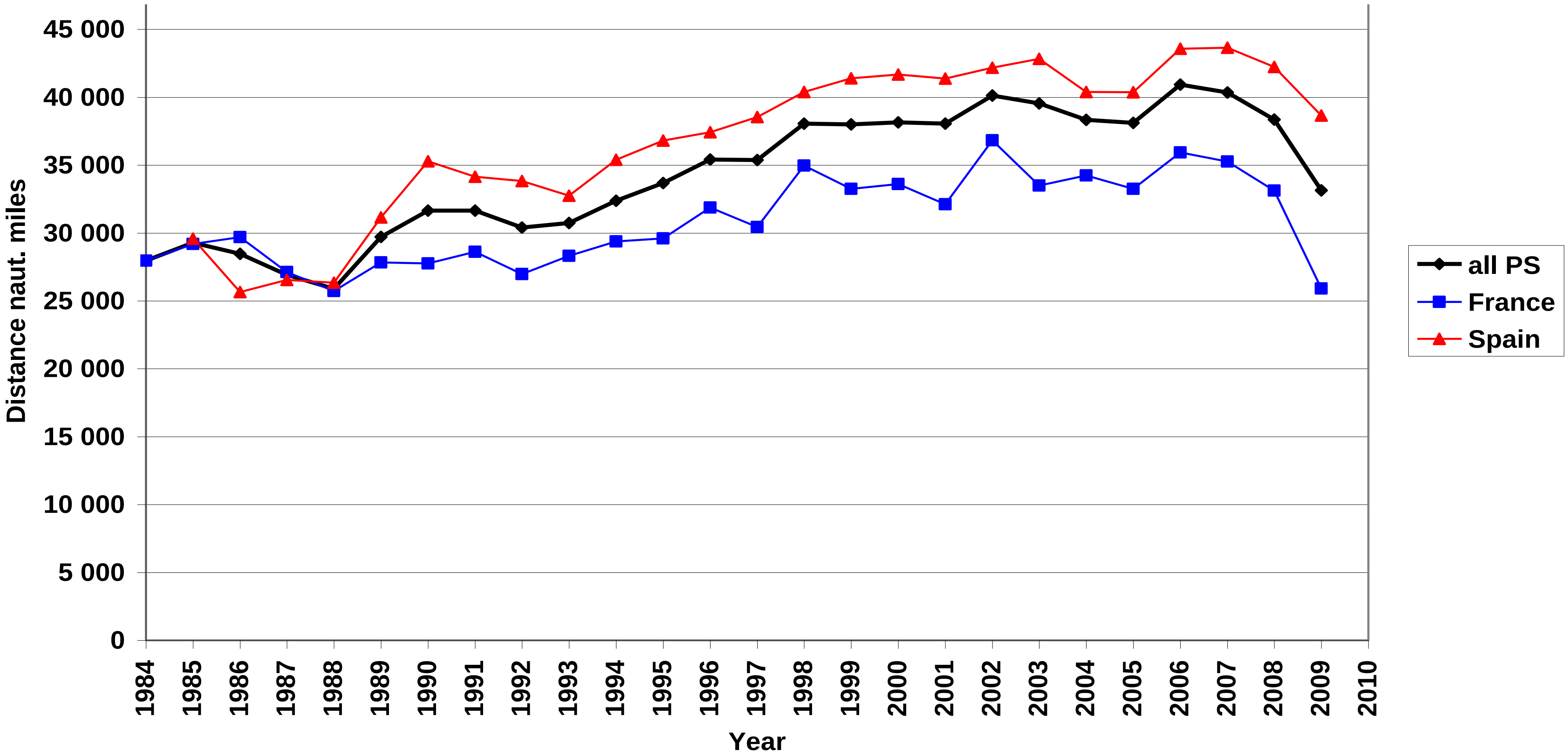
Figure 20 b: Potential effects of supplies on the PS efficiency & SKJ catchability?

1) Supply vessels are large vessels (30-40 meters long) with a significant daiy cost
2) They increase the potential catches of associated PS, mainly FAD & SKJ catches, and they also reduce their operating cost (reference?)
3) They are supporting part of the Spanish+Seychelles fleet
4) There effects upon SKJ cachability of the Spanish/Seychelles fleet could be estimated based on their effect on increased SKJ catches, see the following figure.



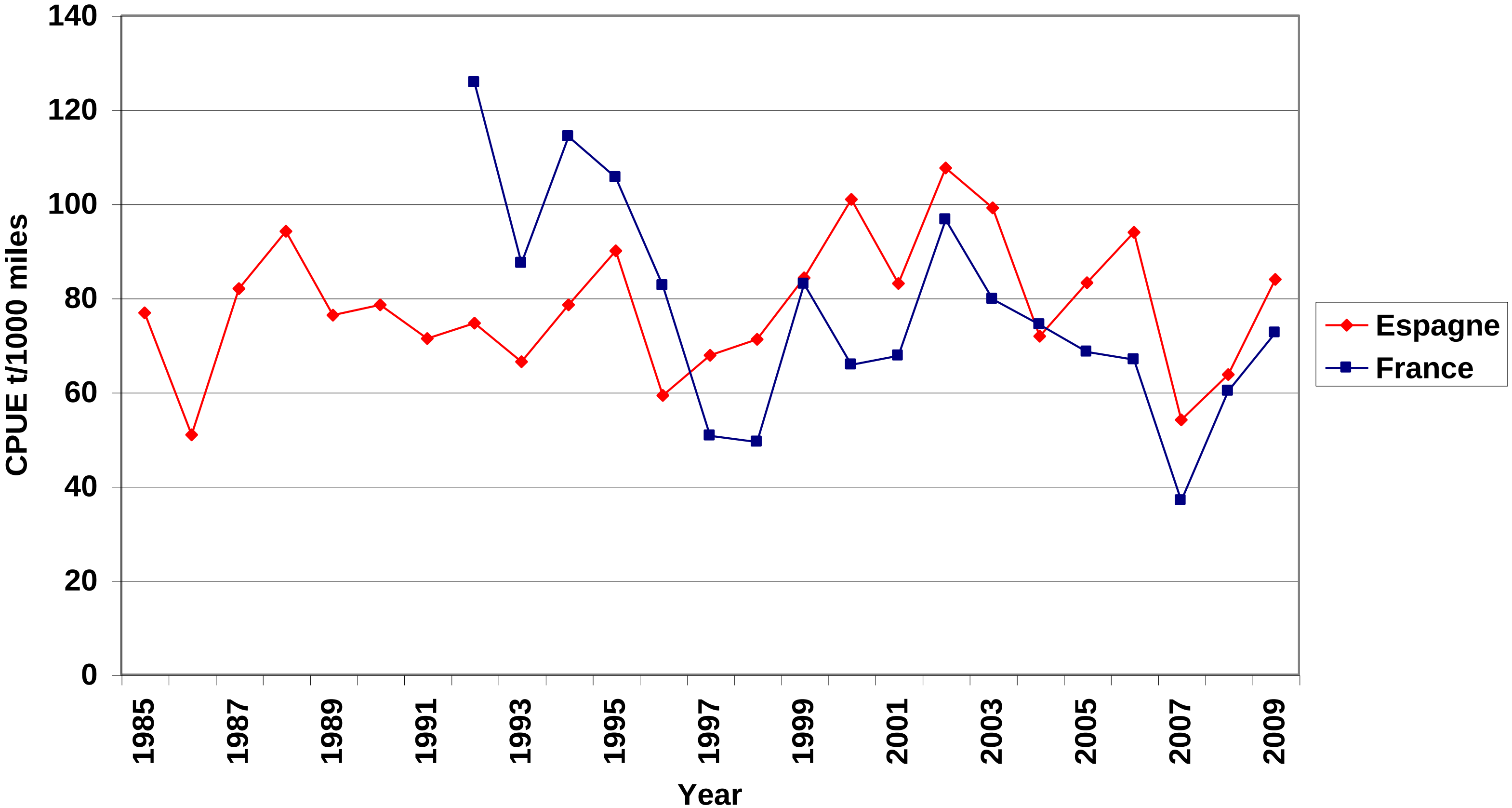
Potential increase of the Spanish+Seychelles PS SKJ effort, based on the hypothetical increase of SKJ catches/CPUE, assuming a 10% and a 40% increase of catch of the associated PS (assuming an association betwteen 1 supply and 1 PS).

Figure 21: Changes in the average distances travelled by PS per 1000 fishing days



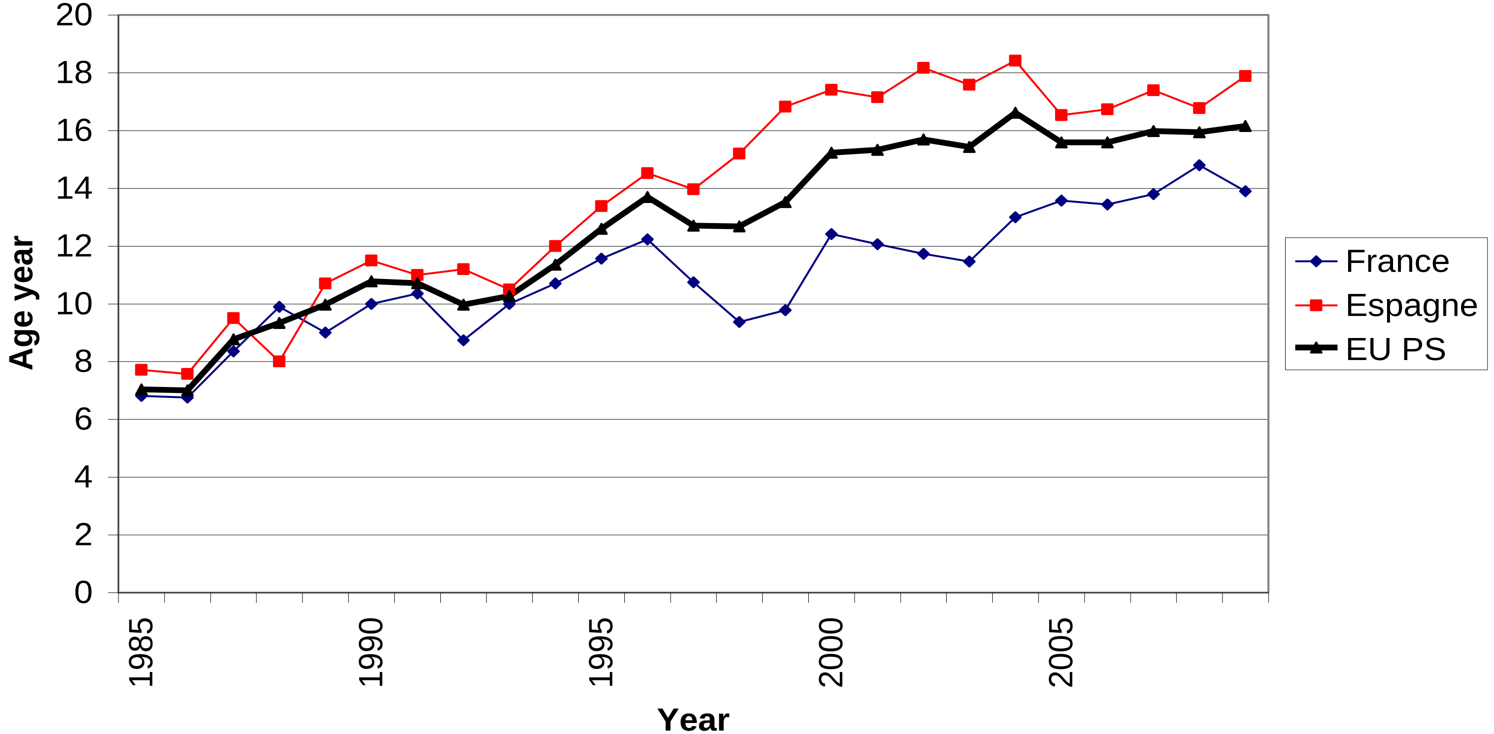
1) Log book data tend to show that the distance covered yearly by each PS have been widely increasing during the 1988-2006 period, and declining since 2007
2) Distances explored yearly by Spanish+Seychelles PS are always more important than distances explored by French PS

Figure 22: SKJ CPUEs by 1000 Nautical miles, medium size PS: 1250-2000 tons of carrying Cap



SKJ CPUEs of a given size of PS, for instance medium size PS of 1250-2000 tons of carrying Capacity, calculated by 1000 Nautical miles tend to be stable or declining & at similar levels for both fleets.

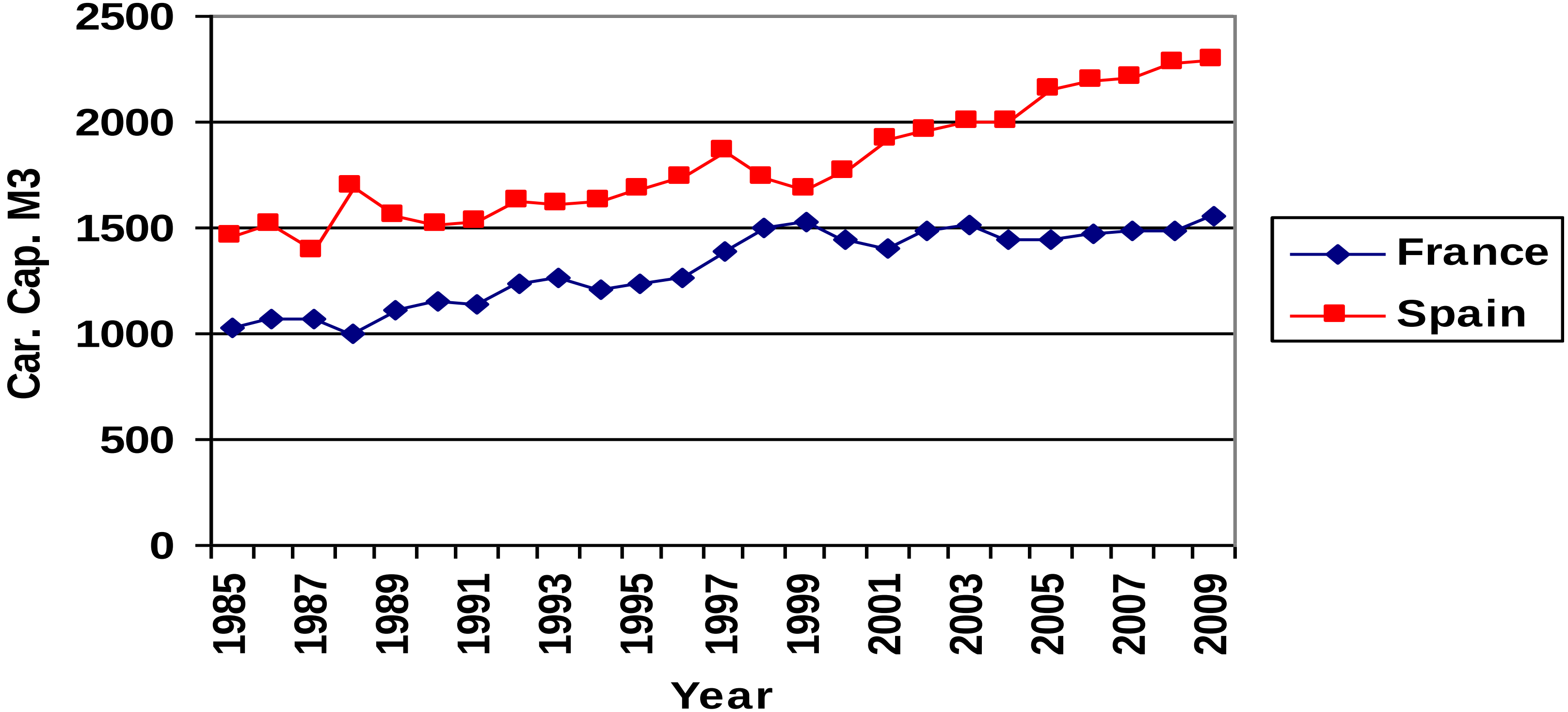
Figure 23: Changes in the age of PS: reduced efficiency?



1) Ageing of a PS fleet may reduce its efficiency, but this potential effect is very difficult to evaluate.
2) Spanish+Seychelles and French PS fleets have been ageing in the Indian Ocean: reaching a plateau since 2000 (16 years for the combined fleet)
3) The average Spanish+Seychelles PS are older due to several very old PS still in activity.
4) *Taking into account that the average age of the PS fleet was stable and reasonably young (compared to the Atlantic: 25 years), it could be hypothesized that the age of the PS fleet was not a source of declining fishing efficiency*.

Figure 24 a: Average carrying capacity of PS

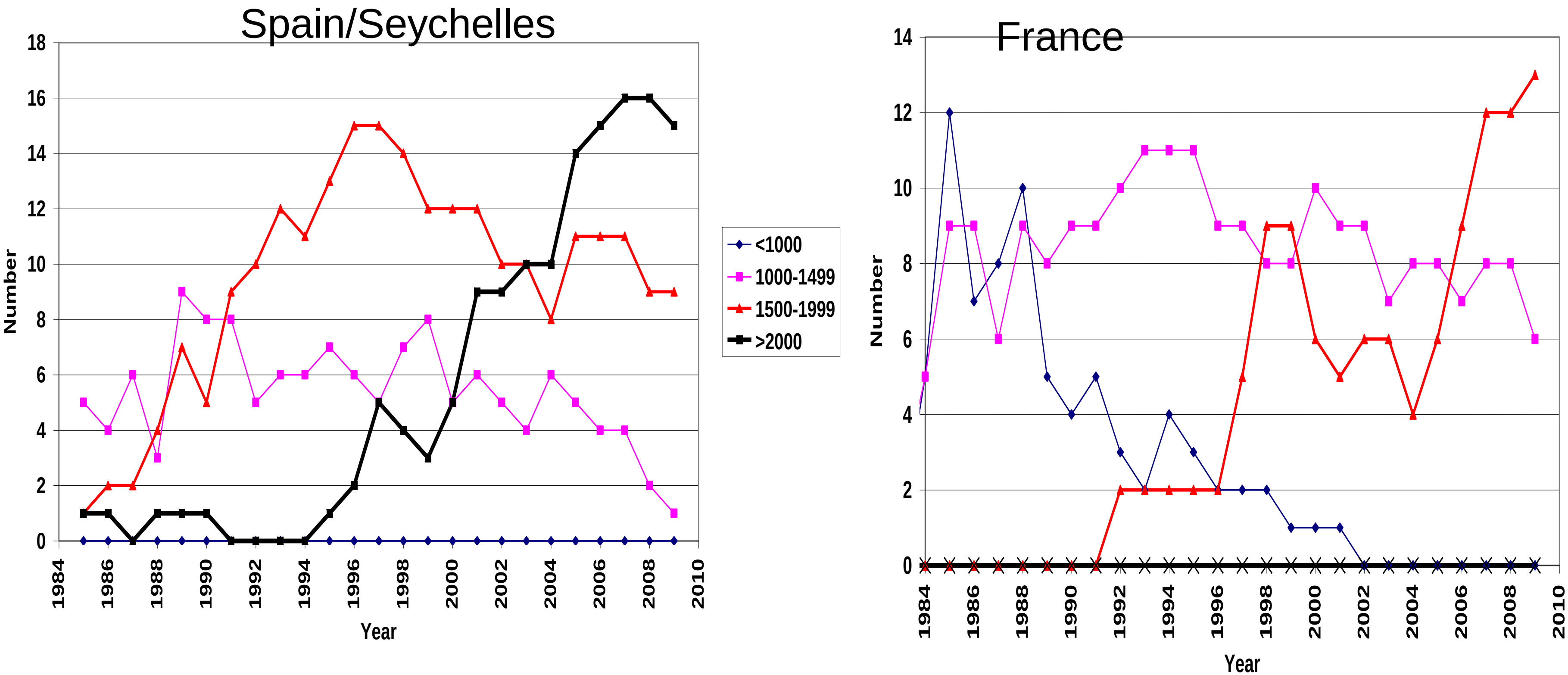
NB: a parameter easily handled in GLMs



1) A steady increase of average fishing capacity observed for both French and Spanish+Seychelles PS during the entire period 1985-2010
2) Much larger capacity observed for the Spanish+Seychelles fleet (average close to 2400 m3 vs 1500 m3 for French PS)

NB: These large differences in capacity would easily explain (a) the differential species targeting of the 2 fleets (larger vessels leading to more targeting on FADs an on SKJ) and (b) the better CPUEs and catch per vessel of the Spanish+Seychelles fleet (larger vessels with larger potential yearly total catches)

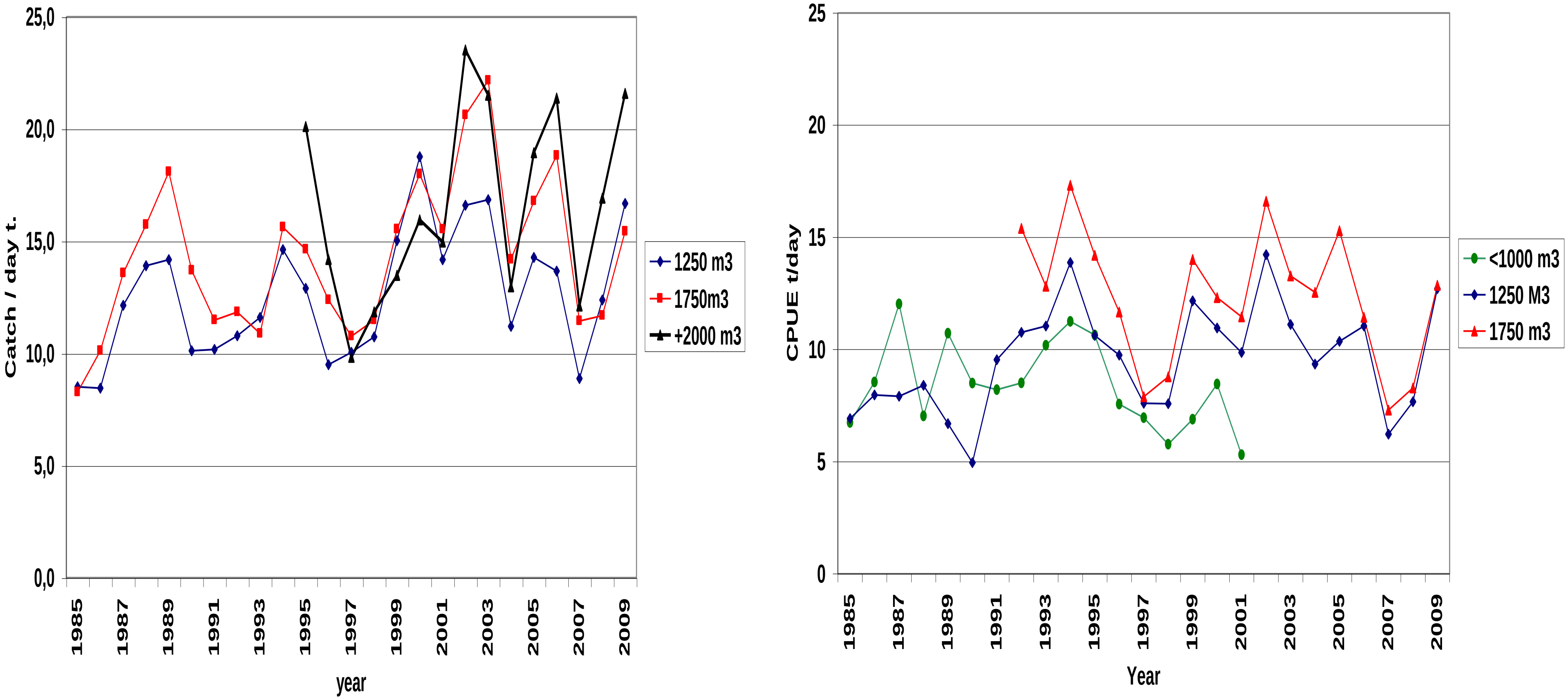
Figure 24b: Numbers of PS by size categories: France & Spain+Seychelles



1) The EU PS fleet can well be stratified in 4 categories: <1000 m3, 1000 to 1500 m3, 1500 to 2000 m3 and over 2000m3.
2) The numbers of PS active each year in each of these categories are shown in this figure: showing major differences in the size composition of the 2 fleets

2 main differences (a) large number of small French PS untill 2002, and (b) large & increasing numbers of large Spanish PS, a category absent in the French fleet

Figure 24c: Sizes of fishing vessels & SKJ CPUEs of Spanish+Seychelles & French PS



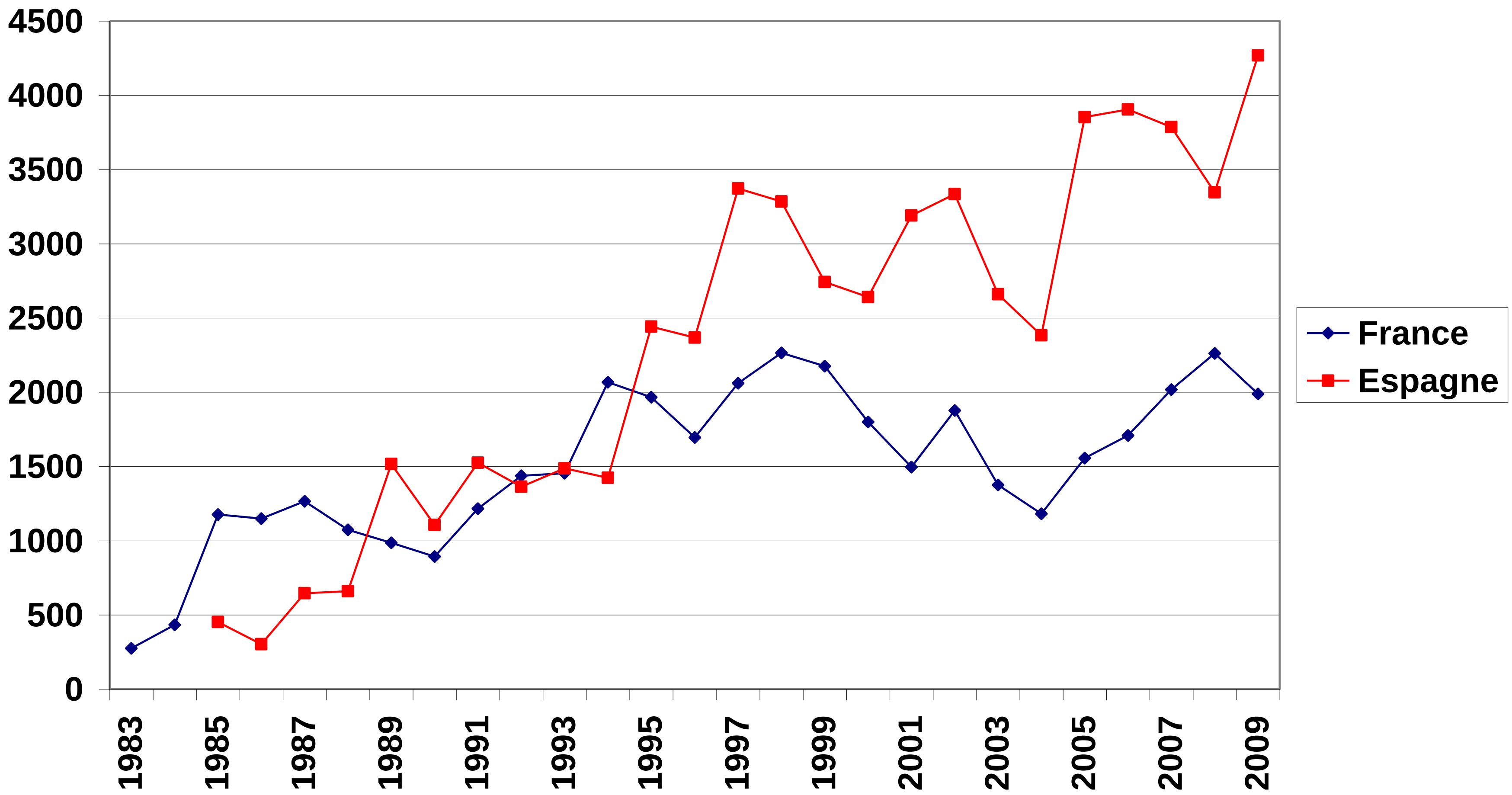
Spain/Seychelles

France

SKJ CPUEs & size of PS: larger PS always showing higher SKJ CPUEs, for both fleets.

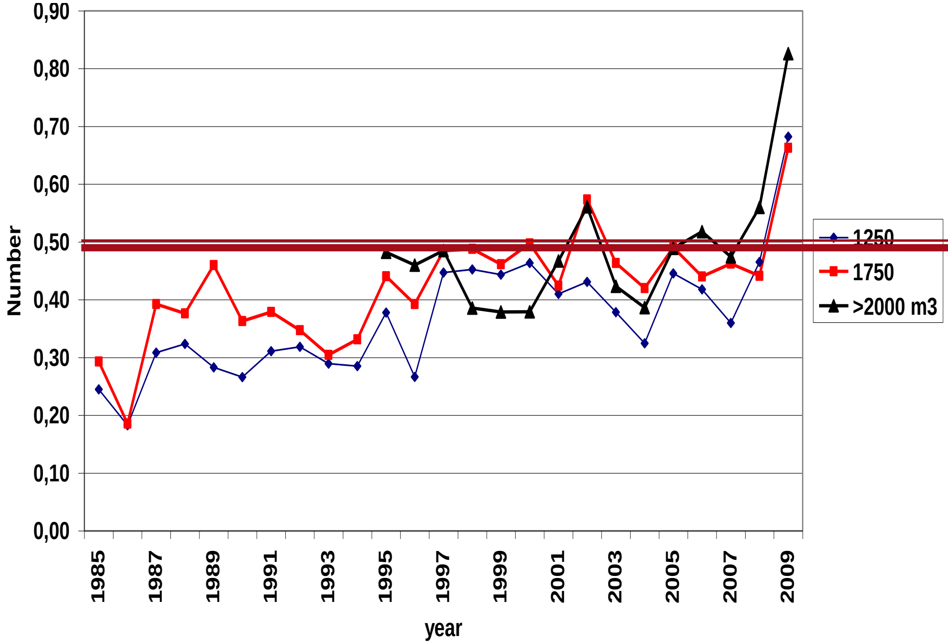
A logical observation observed for both fleets. The increase in PS sizes tend to increase SKJ catchability, especially for the larger Spanish+Seychelles PS that are widely built to target SKJ and FADs, and often with the support of supply vessels.

Figure 25 a: Changes in the numbers of FAD sets

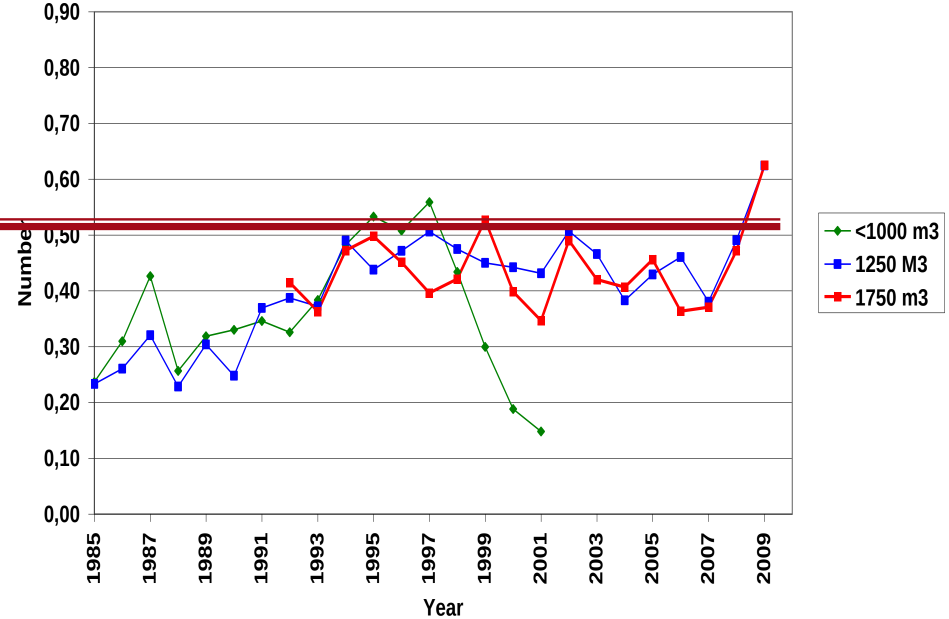


1) Numbers of logs/FAD sets have been steadily increasing for EU PS & especially since 1995
2) Numbers of logs/FAD sets were increasing & nearly identical for French/Spanish+Seychelles PS until 1995
3) Since 1996, they have been fluctuating without trend for France, & increasing for Spanish+Seychelles PS

Figure 25b: Numbers of FADs sets by fishing day, France & Spain+Seychelles, by size categories



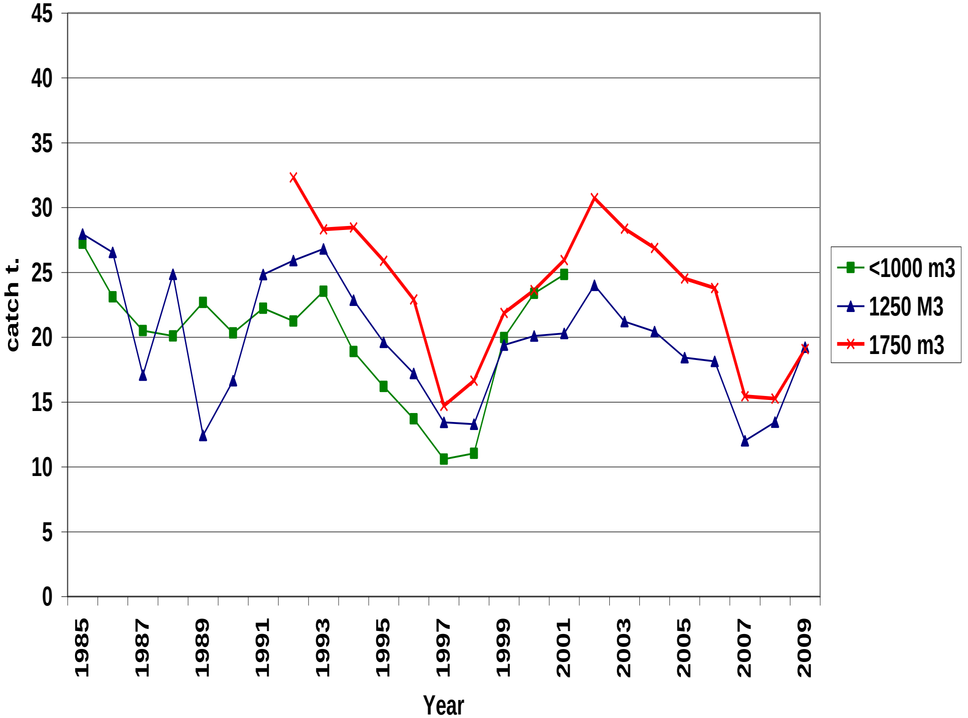
Spain/Seychelles



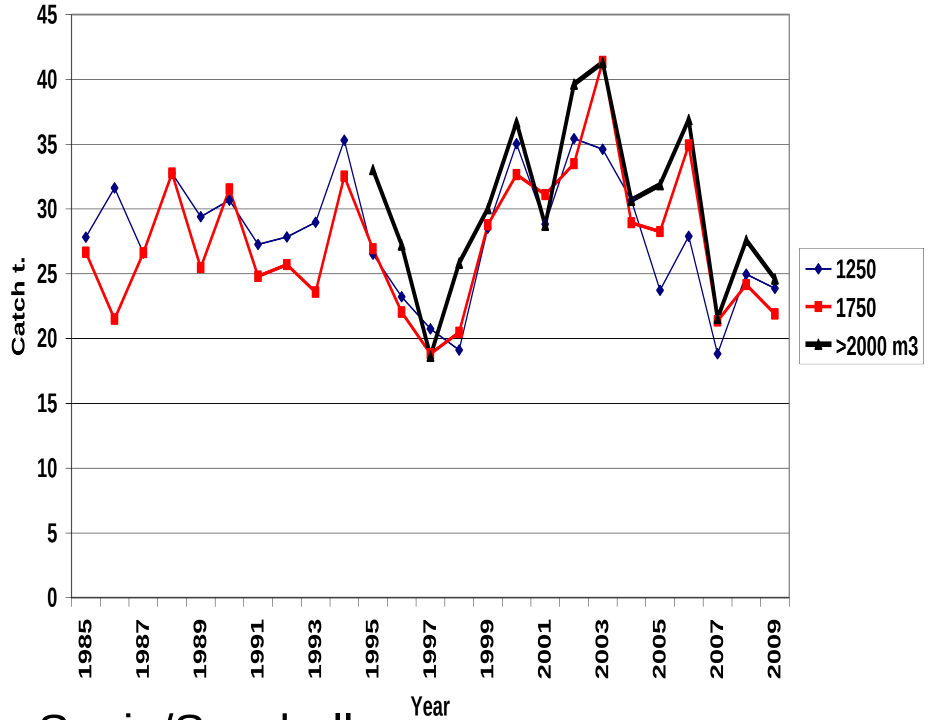
France

1) Number of FAD sets per day are quite independant of size vessels and of flag vessels.
2) Number of FAD sets per day have been increasing during the 1985-1995 period, but since 1995 they remain surprisingly stable
3) Larger numbers of FAD sets observed for large PS >2000 m3 since 2000.
4) Record average catch per FAD sets were observed in 2009 for France & Spanish+Seychelles PS

Figure 26: Changes in the SKJ catches per average FAD set, by PS size categories



France



Spain/Seychelles

1) SKJ catch per set have been fluctuating without clear trend; but a decline has been observed during the last 8 years?
2) SKJ Catch per set tend to be often in proportion of PS sizes, but showing relatively minor differences between PS categories
3) Spanish+Seychelles average catch of SKJ /FAD set of the 2 medium size PS categories were higher for Spain+Seychelles. Period 1995-2009: 27 t vs 20 tons.

Part 3: Changes in the PS SKJ fishery that may be important, but cryptic in traditionnal IOTC fishery data and in EU data bases, and difficult to incorporate in statistical models

1) Unknown numbers of active FADs? Figure 27
2) 20 last years: major improvement in FAD technologies and permanent increase in PS Fishing technology, Figure 28 a & b
3) Negative effects of Somalian piracy: producing cryptic fractions of stock off Somalia and reduced fishing efficiency of PS on SKJ in the Western IO? Figure 29 a & b
4) Value of SKJ & YFT?figure 30 a & b
5) SKJ Effects of changes in skippers: best French skippers moving to Spanish PS, Figure 31

Figure 27: Unknown numbers of active FADs?

- There are very little doubts that the SKJ FAD PS CPUEs are widely dependent of the number of FADs per area, as both the tuna biomass associated to each FADs, as well as the probability of encountering FADs without associated tunas are dependent (1) of the tuna biomass, & (2) of the numbers & density of FADs
- However, these total numbers of FADs active at sea remain most often unknown, and only recent estimates of FAD numbers are available: 2100 during recent years (2005) (Moreno et al 2007)
- A great majority of floating objects fished today are artificial ones: 80% (observers, 2003-2009)
- This serious basic uncertainty should always be kept in mind in the interpretation of PS FAD CPUEs
- Could a conceptual indicator of Active numbers of FADs be estimated by the experts? & used in analysis?

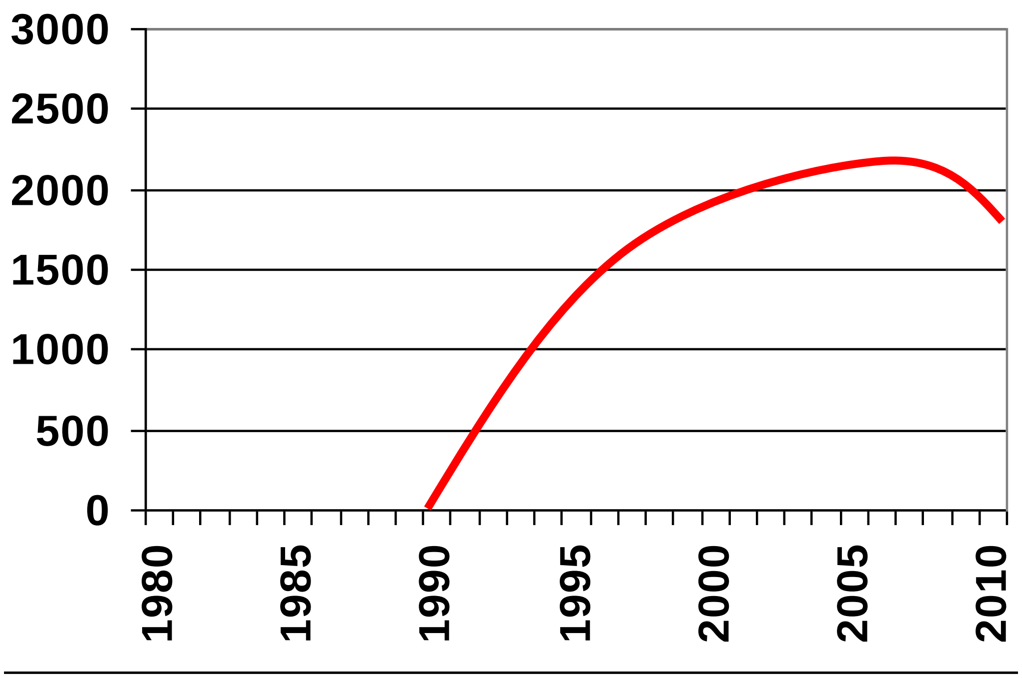


Figure 28a: 1990-2010, 20 last years: major improvement in FAD technologies and FAD targeting

FAD technology could has been permanently improving, allowing:

1) An improved follow-up & localization of FADs, night & day & at increasing distances
2) their improved construction targeting + efficient & + durable FADs (improvements of underlying nets)
3) To increase the number of FADs seeded: using supplies and larger PS
4) To create stealth FADs, that remain + or – cryptic for other PS, not yet for birds!
5) **Since 1985**: Multiple bird radars introduced on all PS allowing to indirectly identify FADs at diostances between 5 to 15 miles
6) Permanent technological progress of bird radars during at least the 1st 25 years
7) Generalization of Echo sounders on FADs, allowing to better target their propoer FADs
8) Idem supply vessels
9) Improved sonars allowing to fish + efficiently on FADs

Unfortunately: there is no way to create an indicator integrating the consequences of all these factors that are potentially increasing fishing efficiency of PS on FADs and then potentially improving SKJ CPUEs. But question should always be kept in mind!

Figure 28b: A permanent increase in PS Fishing technology: nets, sonars, handling of tunas, etc..

+++ Bird radars since 1985

+++ Long range sonars since 2003

+++ Changes in the net characteristics and handling process of net & tunas-→ drastic reduction of setting times and setting the net independently of wind speed

+++ potential to do very large sets quickly, and to freeze quickly these tunas: allowing now to catch large SKJ sets! (for instance Over 200 t.)

+++ Long range sonars generalized since the early 2000ies

++ Many computers heavily used on board by PS skippers and crews

++ Various satellite images received daily and heavily used to better identify the best fishing areas

++ Active use of sonar when setting the PS

+ Navigation radar increasingly computerized and now heavily used on fished tuna concentrations

Figure 29a: Negative effects of Somalian piracy: is it producing a reduced fishing efficiency of PS on SKJ?

Most FADs drifting towards Somalia coasts tend to be lost since 2007….

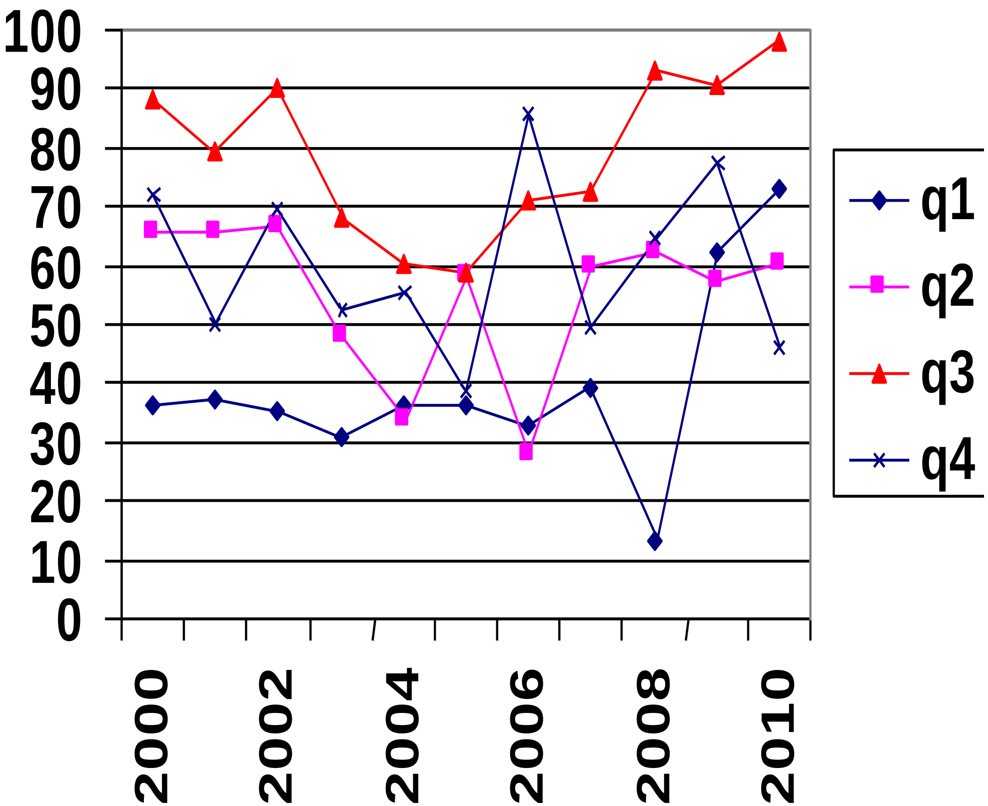
Military staff on board all the EU PS since July 2009 (French) or October 2009 (Spanish and Seychelles PS)

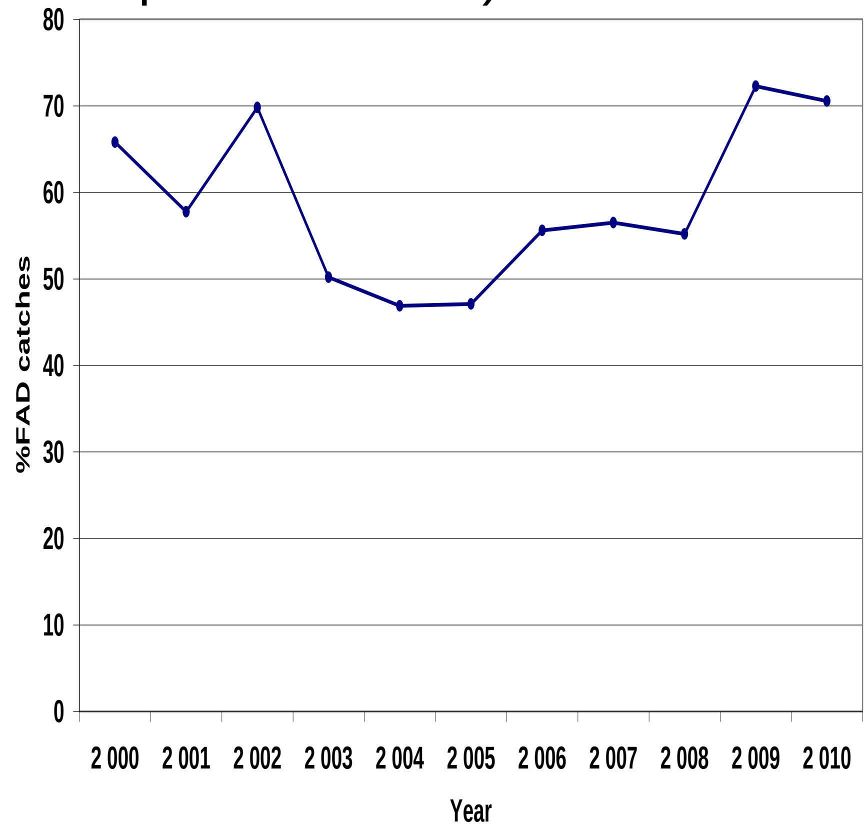
These military staff probably play a negative role on the PS fishing efficiency of French PS: in general & on SKJ.

This loss of fishing power is due for the French PS to various additive factors:

1) Until summer 2011: All French PS have been fishing by couples of boats, with limitation in the fishing activities of each PS, leading to a tendency to reduce free school searching and to increase FAD targeting? But this hypothesis remains questionable, see following figure.
2) French PS: doing shorter trips, 30 days instead of 45 days, then reduced fishing zones and probably producing a global loss of fishing power (& on SKJ)
3) On the opposite: Spanish+Seychelles PS facing a much lower reduction or no reduction of their fishing power, as their militaries do not alter their « fishing patterns »

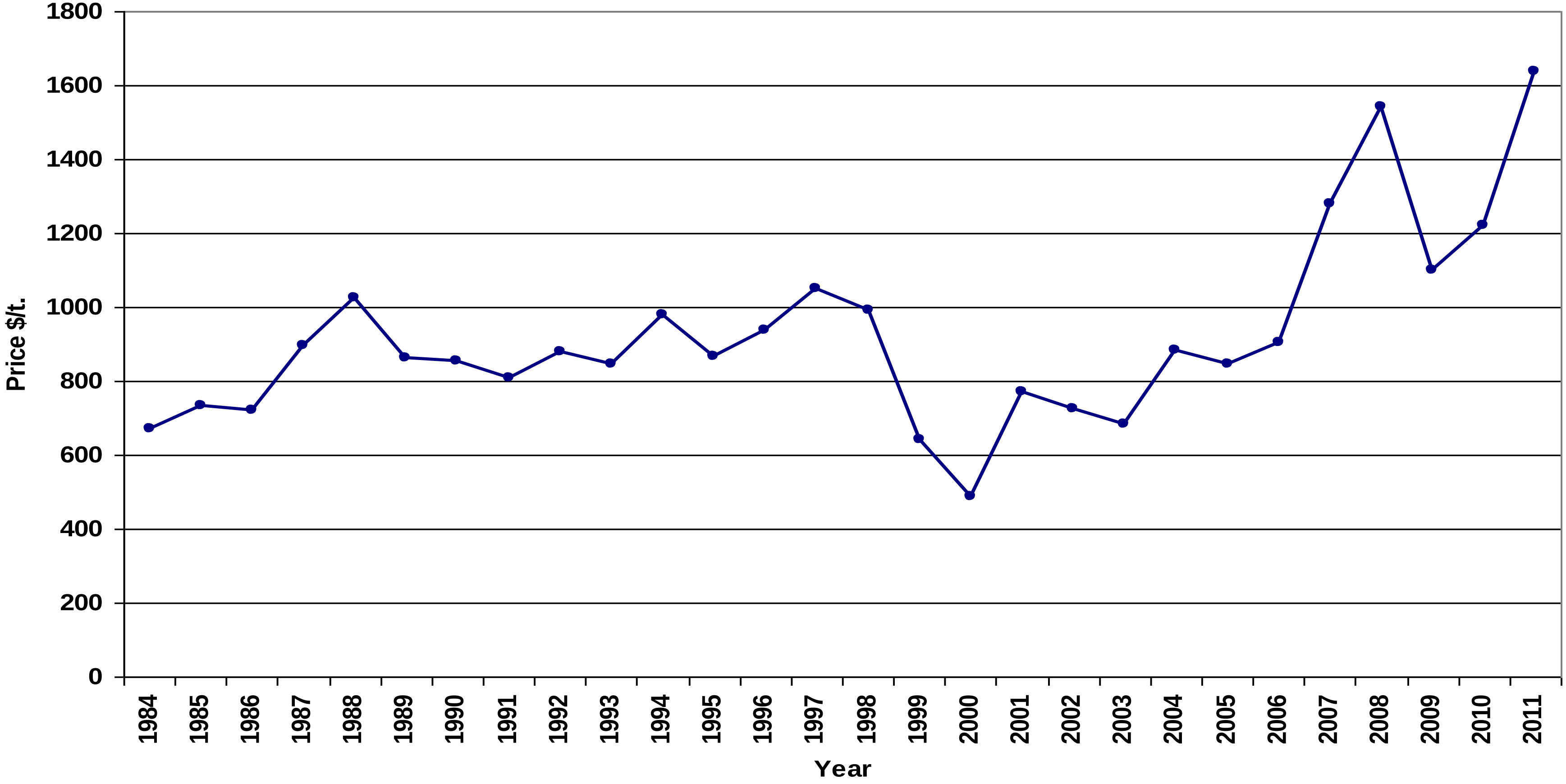
Figure 29b: Quarterly & yearly % of FAD associated catches for French PS
(militaries onboard since the 3rd quarter of 2009)





High % of FAD catches since the 3rd quarter of 2009: 2009 & 2010 showing high % of FAD catches over 70%, but not a major shift towards FAD fishing

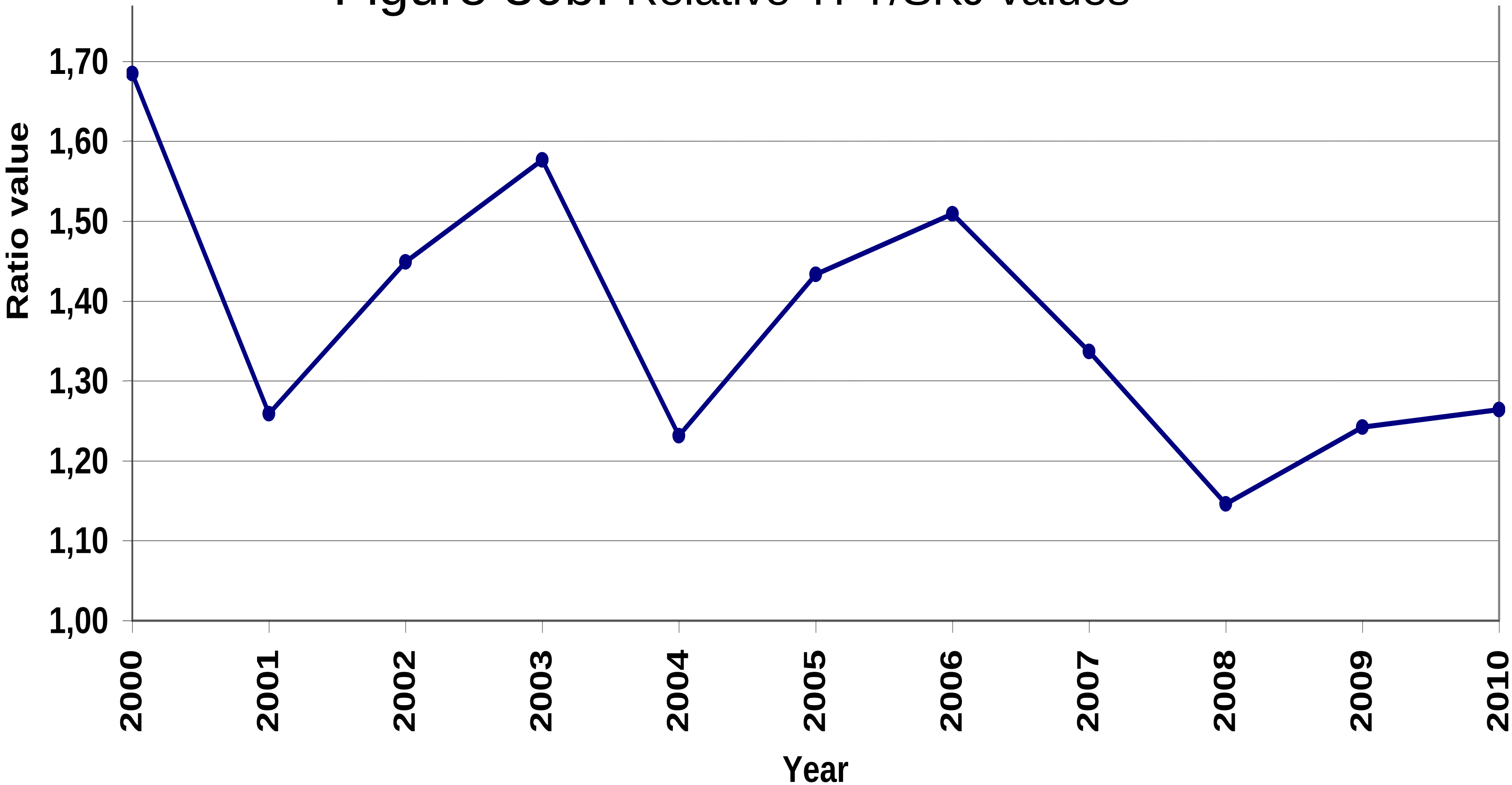
Figure 30a: Absolute landing value of SKJ



Seldom used in CPUEs indices, but the value of SKJ may easily condition the SKJ targetted effort! Major Increase in SKJ value since 2007….. Potentially increasing tagetting of SKJ by PS, One way or another….

For instance very low values in 2000, probably reducing pressure on SKJ at least for French PS, and recent SKJ high values: probably increased fishing pressure on SKJ…

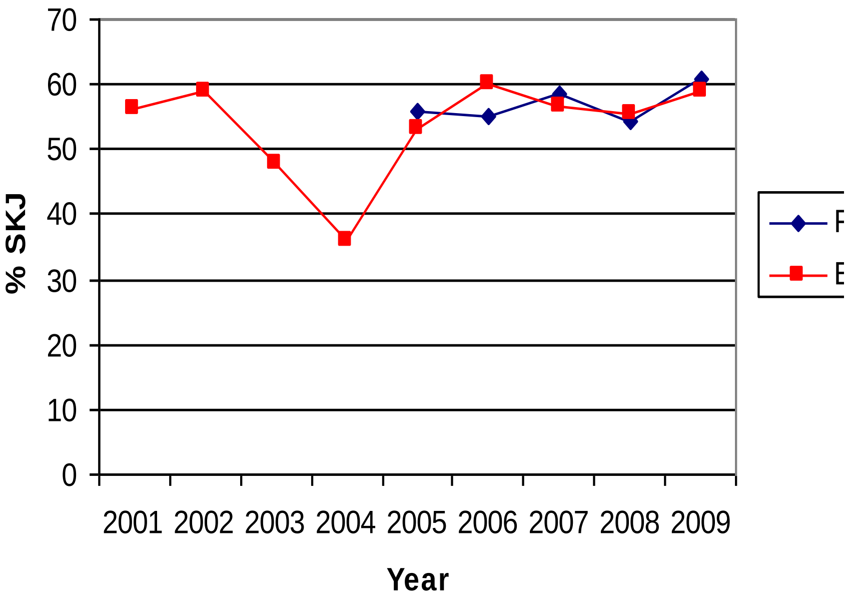
Figure 30b: Relative YFT/SKJ values



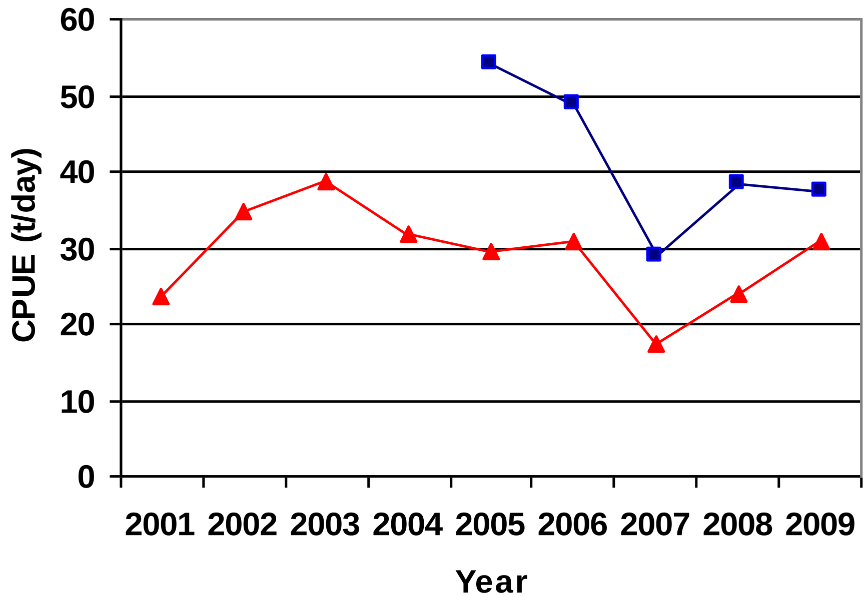
Relative price of YFT vs SKJ tend to fluctuate, but without clear trend between 2000 & 2007.. Since 2008, the absolute SKJ prices have been increasing & the relative value of SKJ has been very high, only 15 to 28% less than large YFT, then putting more pressure on skippers to target SKJ, for instance when compared to 2000, 2003 and 2006, when SKJ prices were very low.

Figure 31: SKJ Effects of changes in skippers: best French skippers moving to Spanish PS

-Already 5 transfers of good French skippers, contracted by a Spanish company,
-All working on large PS >2000 m3
-Dates: Dec 2005, Feb 2007, April 2007, May 2010, January 2011
-A frequent hypothesis by scientists, was that the goal of these recruitments was to increase catches of free schools & of large YFT.
-In these hypothesis, these transfer could decrease the efficiency of FAD fishing and then also of the SKJ catchability on these 5 PS



% of SKJ taken by Spanish PS with French and Spanish skippers tend to be identical: **no visible decline in SKJ q!**



Spanish PS >2000 m3 Cap.: Average CPUE of Spanish and French skippers; French skippers are positionned on the best Spanish PS,

Conclusion from SKJ indicators

1) There are no doubts that the Indian Ocean SKJ stock has been increasingly fished and depleted during the last 30 years.
2) Increasing fishing powers of BB & PS and the more efficient & increased use of FADs are increasing fishing efficiency on SKJ and (probably), thus widely masking the logical decline of SKJ biomass
3) GLM CPUE index would have major difficulties to integrate the multiple parameters conditionning the fishing efficiency & the CPUE biomass relationship.
4) Recent reduction in the catches of large SKJ taken by PS and BB fisheries are probably an additional indicator of an heavily fished SKJ stock
5) Somalian piracy did produced during the last 5 years: (1) changes in fishing zones, (2) in fishing patterns of PS, (3) a decline of fishing effort of PS, (4) a decline of supply vessels, (5) then a decline of SKJ catches
6) But but not necessarily of the Fishing mortality suffered by the SKJ stock: the decline of average weight probably corresponds to higher Exploitation rates of the SKJ stock.
7) Furthermore, the high value of SKJ observed since 2008, probably increased the fishing pressure on SKJ, one way or another…
8) This complex combination of SKJ indicators should be kept in mind if complex models are developped to model the SKJ stock status in an integrated way.