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IMPACT OF CLIMATE ANOMALY ON CATCH COMPOSITION OF NERITIC TUNA IN SUNDA STRAIT (EASTERN PART OF INDIAN OCEAN)

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ABSTRACT

Tongkol komo/kawa-kawa (*Euthynnus affinis*) and tenggiri (*Scomberomerus guttatus)* are commonly caught by mini purseneirs operated in Sunda straits and landed in Labuan, West Java. This species inhabit around coastal water and has preference staying in relatively warm water. Oceanography parameters which commonly influence the distribution of *Euthynnus affinis* are temperature, current, and salinity. The oceanography of Sunda strait is influenced by water masses comes from the north that mainly originated from the Jawa water mass and water masses from the south mainly originated from Indian ocean. The internal oceanography of sunda strait is also influenced by upwelling and monsoon as regional cimate anomaly (ENSO and Indian Ocean Dipole Mode). This paper describe the influence of *Dipole Mode* (Positive and negative event) and ENSO (El-Nino/La-Nina) to the cacth dynamics of *neritic tuna* particularly in Sunda straits waters by *time series* from 1994 to 2009. The result shown that regional climate anomaly influenced of neritic tuna catch and ist composition. The catches of *Euthynnus affinis* in phase negative dipole mode or La-Nina was higher and dominate the catch composition of pelagic fishes of sunda strait. Similar situation also showed by *Scomberomorus commerson* as a more coastal species.

1. Introduction

Longtail tuna (*Thunnus tonggol*), frigate tuna (*Auxis thazard*), bullet tuna (*Auxis rochei*), kawa-kawa (*Euthynnus affinis*), narrow-barred Spanish mackerel (*Scomberomerus commerson*) dan Indo-Pacific king mackerel (*Scomberomerus guttatus*) are common species of *neritic tuna* caught in Indonesian water. Muripto (2000) reported tongkol komo/kawa-kawa (*Euthynnus affinis*) and tenggiri (*Scomberomerus guttatus)* are commonly caught by mini purseneirs operated in Sunda straits and landed in Labuan, West Java.

IOTC (2006) reported that *Euthynnus affinis*, inhabit around coastal water and has preference staying in relatively warm water 18°- 29°C. Facultatively these species are able to make school up to 400 m depth. Oceanography parameters which commonly influence the distribution of *Euthynnus affinis* are temperature, current, and salinity (Hela & Laevastu, 1970). Gunarso (1985) also reported, *Euthynnus affinis* susceptible to temperature and salinity from 0.03 ^{0}C and 0.02 ‰.

Length distribution of *Euthynnus affinis* caught in sunda straits was varry according to the seasons (Muripto, 2000). First transition (February-March-April) 22,0-59,0 cm FL in 1998 and 17,0-52 cm FL in 1999; East monsoon (May-June-July) 17,0-58,0 cm FL in 1998 and 12,0-51,0 cm FL in 1999; Second transition (August, September-October) 13,0-50,0 cm FL in 1998 and 16,0-51 cm FL in 1999; and west monsoon (November-December) 33,0-34,0 cm FL in 1998 and 21,0-44 cm FL in 1999. Length distribution of *Scoromberomorus guttatus* within first transition season was 33,0-96,0 cm FL in 1998 and 26,0-52,0 cm FL in 1999; East Monnsoon 37,0-74,0 cm in 1998 and 35,0-44 cm FL in 1999; and during second transition was 37,0-58,0 cm in 1998 and 37,0-69,0 cm in 1999.

Labuan fishers operate two kind of fishing gears that is mini purse seiners and danish seine (payang) both are operating in daily basis. The mini purse seiners is night fishing while danish seine conducting the fishing during the day. Both fleet have relatively similar fishing ground from Banten coast to depth of 200 m to the south variously according to the seasons (Muripto, 2000).

To date there is limited information that adress the influence of regional climate anomaly to fisheries resource specifally neritic tuna in Indonesian water. This paper describe the influence of *Dipole Mode* (Positive and negative event) and ENSO (El-Nino/La-Nina) to the cacth dynamics of *neritic tuna* particularly in Sunda straits by *time series* from 1994 to 2009.

2. Materials and Methods

Research location was in Sunda strait Eastern part of Indian Ocean, geographically located whithin 102.5^{0} - 108.0^{0} E and 4.5^{0} - 7.5^{0} S (Figure 1).

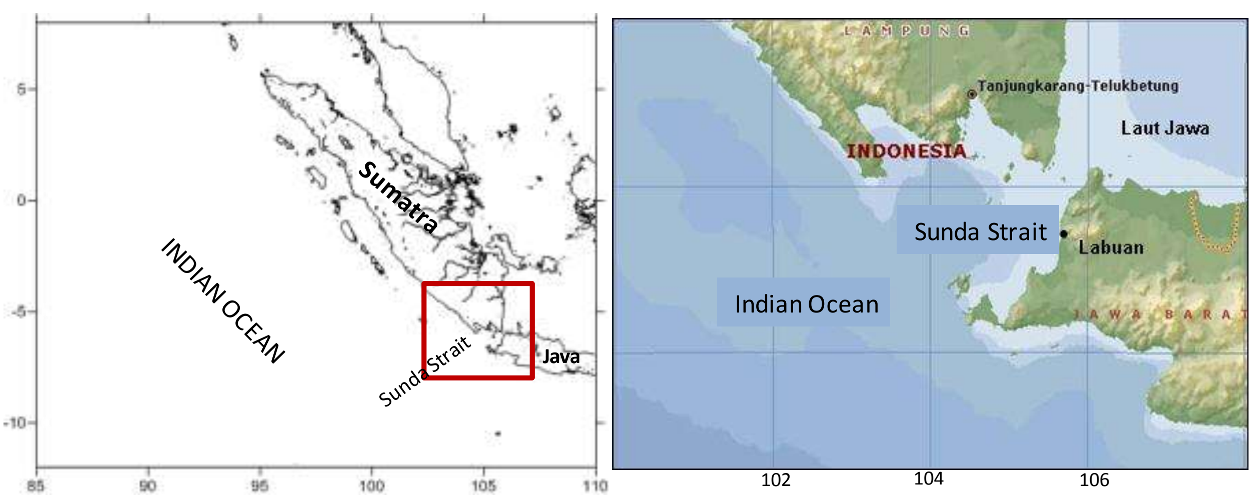


Figure 1. Research area located in Sunda strait

Regional climate anomaly that influence internal condition of Sunda strait oceanography is El-Nino/La-Nina (ENSO) and Indian Ocean Dipole Mode/IOD (Samsudin *et al*, 2003). El-Nino/La-Nina events from 1994 to 2010 are showing in the following graphic (figure 2) and table 1.

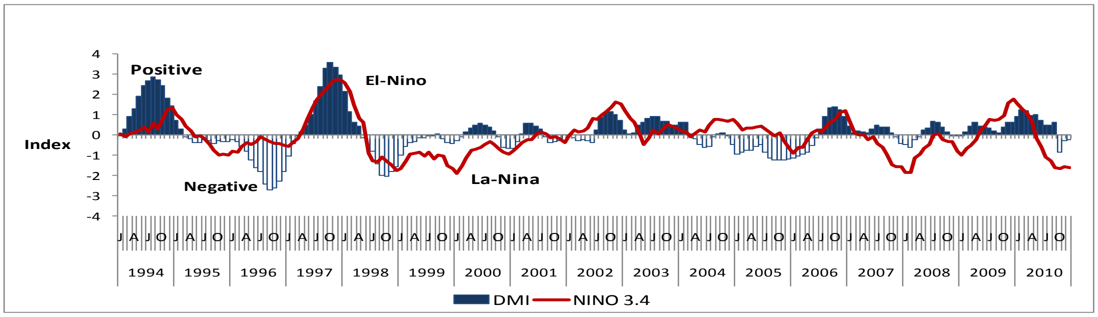


Figure 2. Dipole Mode Index (DMI) and Nino 3.4 Index (Amri, 2012)

Table 1. Event of Dipole Mode and its association with ENSO (El-Nino/La-Nina)

DIPOLE MODE		Association	ENSO		NORMAL	YEAR
Positive	Negative		El-Nino	La-Nina		
strong		+	moderate			1994
				moderate		1995
	strong					1996
strong		*In-phase*	strong			1997
	moderate	+		moderate		1998
				moderate		1999
				weak		2000
					normal	2001
			moderate			2002
weak						2003
			weak			2004
				weak		2005
strong		+	weak			2006
weak		+		moderate		2007
weak						2008
			moderate			2009
				strong		2010
			weak			2011
			weak			2012

(Amri, 2012, JAMSTEC, 2012, BMKG, 2012)

Available data on *Euthynnus affinis* and *Scoromberomorus guttatus* catches were integrated with climate condition particularly in years 1994 (IOD Positive (strong) + El-Nino (moderate)); 1995 (La Nina (moderate); 1996 (IOD Negative (Strong)); 1997 (IOD Positive (strong) *in-phase* El-Nino (strong)); 1998 (IOD Negative (moderate) + La Nina (moderate)); 1999 (La Nina (moderate)); 2000 (La Nina (weak)); 2001 (Normal); and 2002 (IOD positive (weak)+ El Nino (weak); and 2012 (El-Nino (weak)).

Catch data were compiled from fish auction II (TPI II) Labuan specifically monthly catch that landed from mini purse seiners and danish seiners from 1993 to 2003 as well as total catch data from 1994 to 2008.

Climate anomaly (*dipole mode* and ENSO) is indicated from anomaly of Sea Surface Temperature (SST). Satellite image SST was gathered from thermal AVHRR (Advanted Very

High Resolution Radiometer) sensor within 1994-2000 (http://poet.jpl.nasa.gov/) and MODIS (*Moderate Resolution Imaging Spectroradiometer*) sensor within 2001-2012 (http://gdata1.sci.gsfc.nasa.gov/). SST utilized standard algorithm MODIS 11 µm NLSST Algorithm (http://nasa.gsfc.gov). Chlorophyll-a images capture from MODIS sensors (http://gdata1.sci.gsfc.nasa.gov/) and predicted base on algorithm OC3M (O'Reilly *et al*., 2000).

Descriptive analysis were conducted to compare the catch pattern of *Euthynnus affinis* and *Scoromberomorus guttatus* particularly on years that climate anomaly occurs

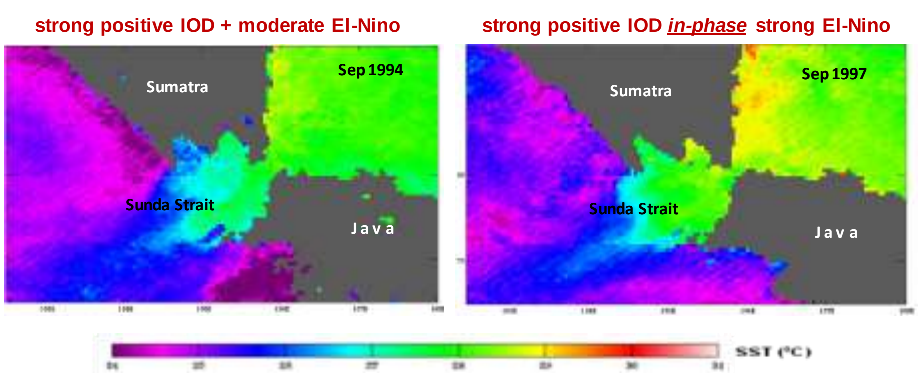
3. Results and Discussion

Oceanography pattern of Sunda Strait

The oceanography of Sunda strait is influenced by at least two water masses i.e: the water masses comes from the north that mainly originated from the Jawa water mass and water masses from the south mainly originated from Indian ocean. Water masses from Jawa have lower salinity and high temperature which influenced by java inland while water masses from Indian Ocean were more oceanic with high salinity and low temperature. The two water masses mixed in the central of the straits and situated according to the current level of each water masses.The current from southern strait i.e South Java Current (Arus Pantai Selatan Jawa/APJ), South Equator Current (Arus Khatulistiwa Selatan (AKS)) and Monsoon Current (arus Musim (AM)), While the current from northern strait is dominated by Armondo (Arus Musim Indonesia). Sometime, the internal oceanography of sunda strait is also influenced by upwelling (Muripto *et al*. 2000; Hendiarti *et al* 2003) and monsoon as regional cimate anomaly (Samsudin, *et al*. 2003).

Sea Surface Temperature

Climate anomaly occured in 1994 (Positive strong IOD *in-phase* moderate El-Nino); 1997 (Positive strong IOD *in-phase* strong El-Nino); and 2006 (Positive strong IOD inphase weak El-Nino) there was water mass from upwelling in the middle and southern strait with high intensity. In this phase the temperature of water mass become much lower compare from its normal condition. The upwelling water mass with moderate intensity also occured in 2002 (moderate El-Nino); 2003 (Weak Postive IOD); 2004 (weak El-Nino); 2009 (Moderate El-Nino); as well as 2011 and 2012 (weak El-Nino) (Figure 3).



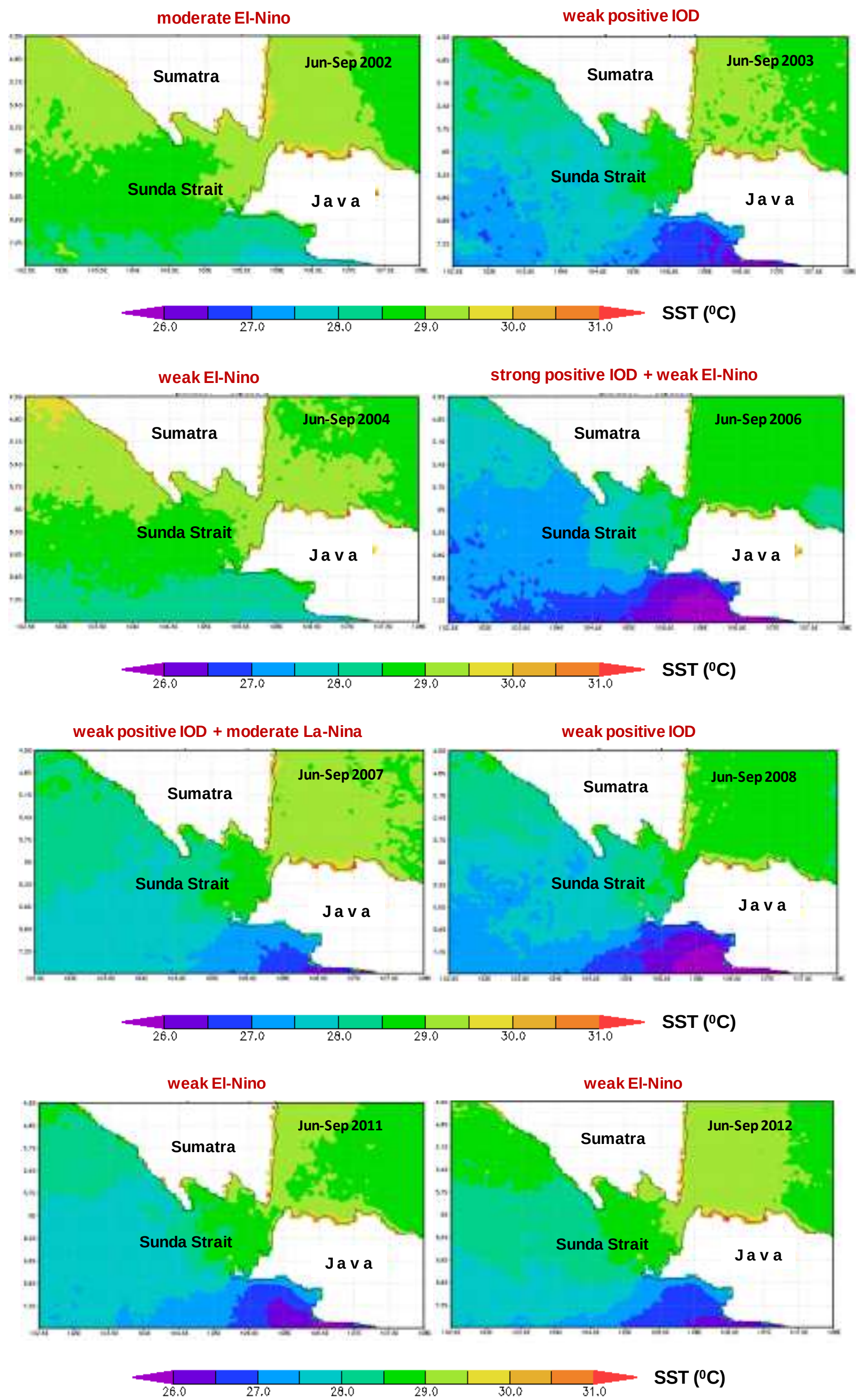
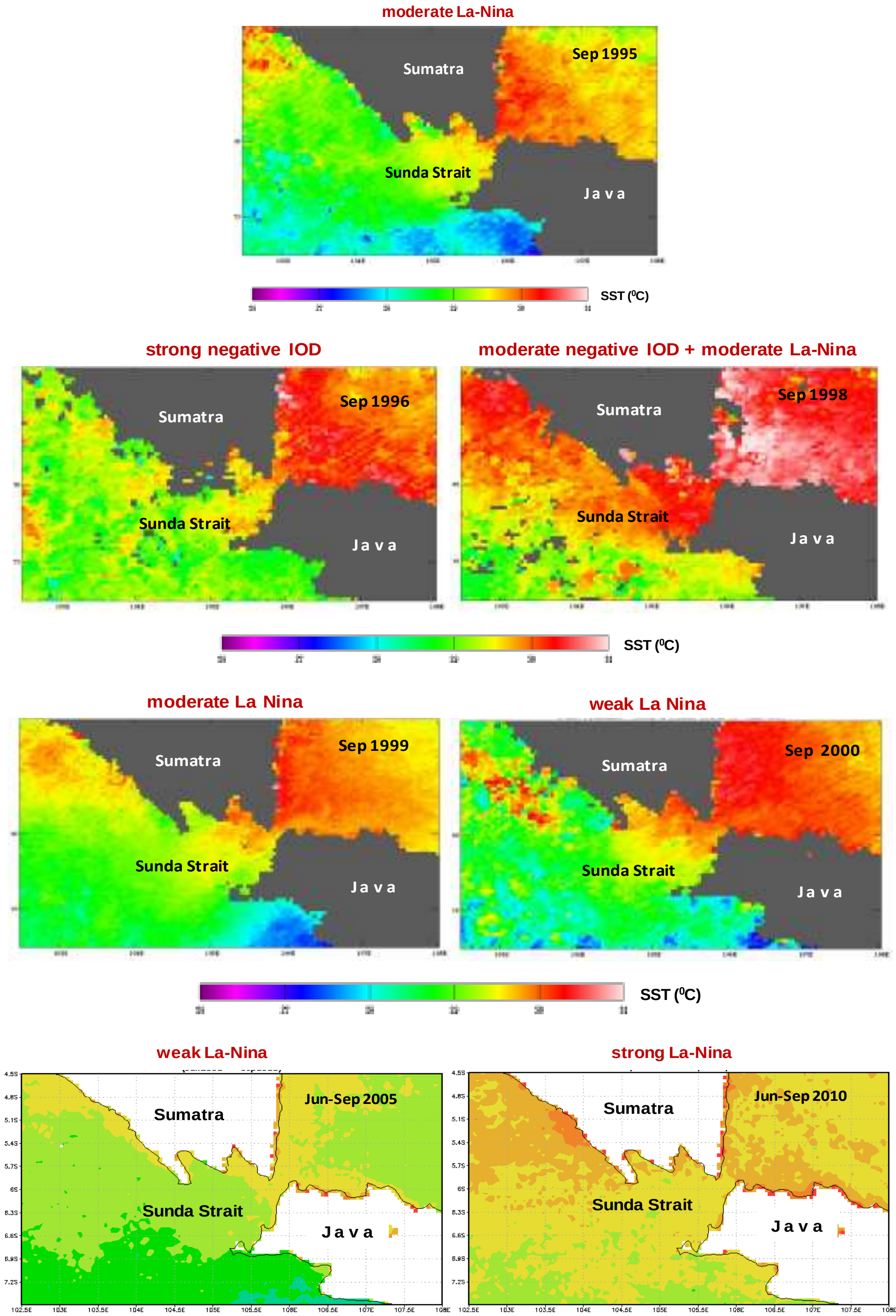


Figure 3. Images of SST on IOD positive and/or El-Nino event (1994-2012)

The other way, when there was negative dipole mode and/or La-Nina, Upwelling did not occur and commonly the water masses have higher SPL disribution than normal condition. This situation recorded and occured in year of 1995 (weak La-Nina); 1996 (Negative strong IOD); 1998 (Negative moderate IOD inphase moderate La-Nina); 1999 (weak La-Nina); 2000 (La-Nina lemah); 2005 (Weak La-Nina); and 2010 (strong La-Nina) (figure 4). In 2001 was a normal year and no influence from IOD and/or ENSO to the sunda strait water (Figure 5).



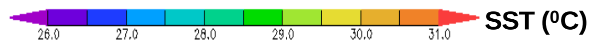


Figure 4. Images of SST on IOD negative and/or La-Nina event (1995-2010)

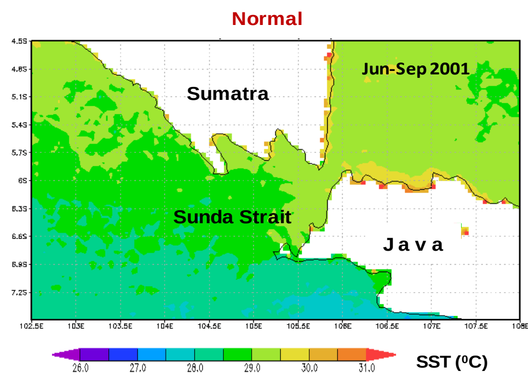


Figure 5. SST Image of Sunda Strait on Normal condition (No dipole mode, no ENSO) (2001)

The SST distribution from each phase from 1994-2012 was presented in table 2 and its fluctuation also shown in the graphic (Figure 6). The lowest average of SPL distribution occured in the phase of strong positive IOD inphase with El-Nino year of 1994, 1997, and 2006 with respective temperature 27.97 ^{0}C (Inphase with moderate El-Nino), 28.47 ^{0}C (in-phase with strong El-Nino) and 28,77 ^{0}C (Inphase with weak El-Nino). The higher average of SST distribution occured during negative IOD or La-Nina phase with range of 30.49-31.29 ^{0}C, When the highest SST occur and found in the phase of strong negative IOD 1996 (31.02 ^{0}C) and moderate negative IOD inphase with moderate La-Nina 1998 (31.29 ^{0}C). The average of SST distribution in the normal phase (2001) was 30.14 ^{0}C.

Table 2. SST range and average value by phenomenon of regional climate anomaly

Phenomenon (Years)		SST (0C)	
		Range	Average
Positive IOD/El- Nino	Strong Positive IOD + moderate El-Nino (1994)	26.40 - 28.98	27.90
	Strong Positive IOD in-phase strong El-Nino (1997)	28.50 - 29.80	28.47
	Moderate El-Nino (2002)	29.50 - 29.98	29.65
	Weak positive IOD (2003)	28.58 - 29.73	29.23
	Weak El-Nino (2004)	28.20 - 29.93	29.14
	Strong positive IOD + weak El-Nino (2006)	28.88 - 29.02	28.77
	Weak positive IOD + moderate La-Nina (2007)	28.98 - 29.93	29.40
	Weak positive IOD (2008)	29.03 - 31.13	30.09
	Weak El-Nino (2011)	28.96 - 31.00	30.24
	Weak El-Nino (2012)	28.93 - 31.09	30.26
Negative IOD/La- Nina	Moderate La Nina (1995)	29.23 - 31.65	30.49
	Strong negative IOD (1996)	29.48 - 31.88	31.02
	Moderate negative IOD vs moderate La Nina (1998)	29.62 - 32.33	31.29
	Moderate La-Nina (1999)	29.03 - 31.58	30.51
	Weak La-Nina (2000)	29.25 - 31.32	30.28
	Weak La-Nina (2005)	29.48 - 32.22	30.63
	Strong La-Nina (2010)	29.49 - 31.00	30.92
Normal	Normal (2001)	29.18 - 31.01	30.14

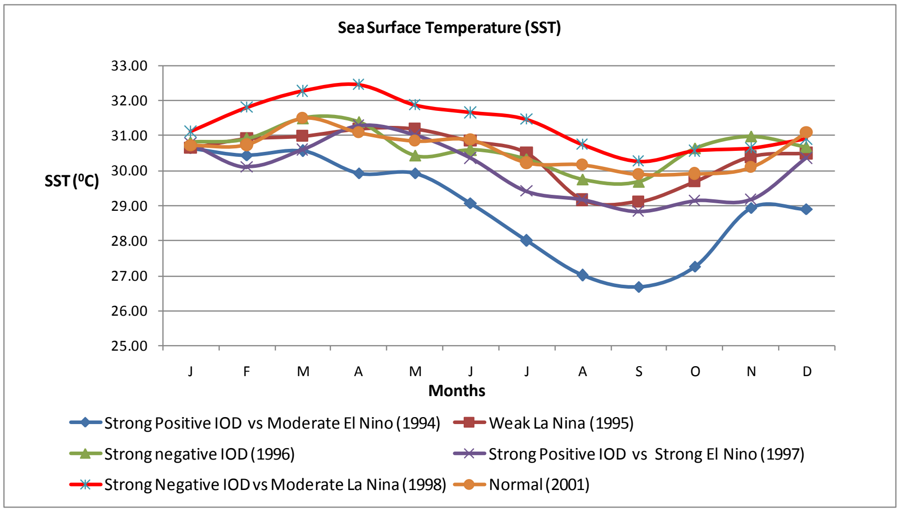


Figure 6. Monthly fluctuation of SST

Sea Surface Chlorophyll

Chlorophyll-a distribution in phase of IOD positive or El-Nino higher than in phase of IOD negative and La-Nina or in normal phase. High distribution of chlorophyll-a in phase positive dipole mode and El-Nino was due to the occurrence of intensive upwelling in that time. The average of SST and chlorophyll-a distribution from 1997-2009 is presented in figure 7.

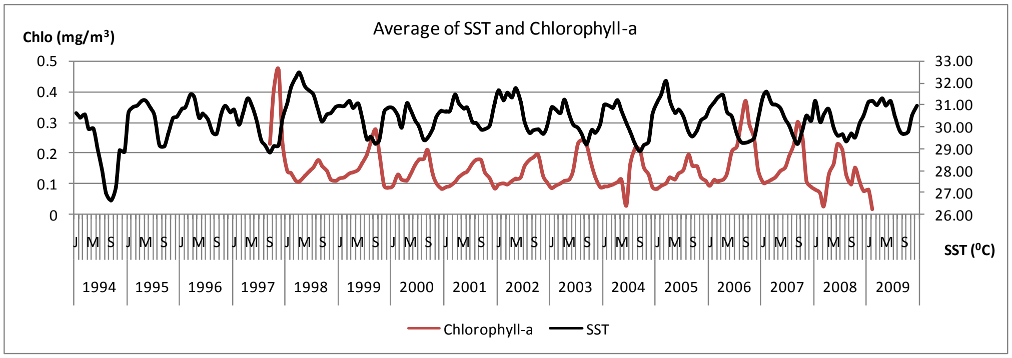


Figure 7. Average value of SST and Chlorophyll-a 1994-2009 in Sunda Strait

Looking at the monthly distribution and fluctuation of chlorophyll-a when climate anomaly occurred (figure 8), revealed that in phase strong positive dipole mode 1997 and 2006 the distribution of chlorophyll-a was very high, on the other side during negative phase of dipole mode and La-Nina the distribution of chlorophyll-a was very low.

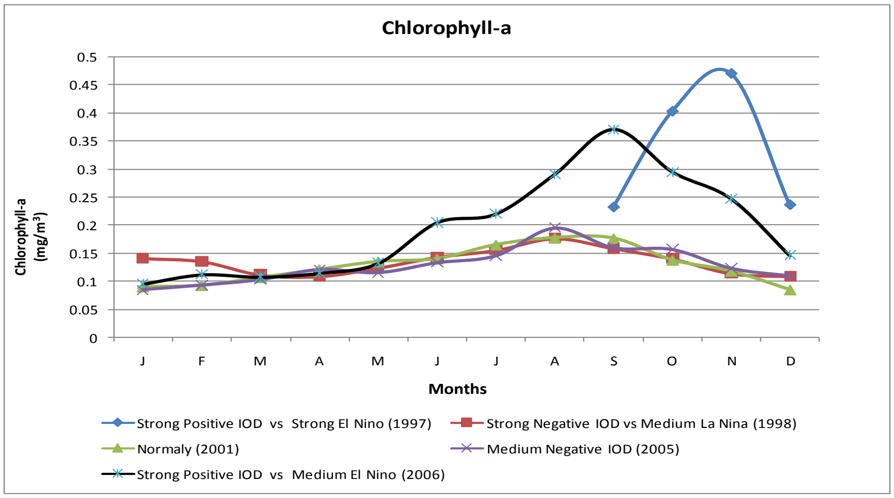


Figure 8. Monthly fluctuation of Chlorophyll-a

Catch Data

Annual catch of small pelagic and neritic tuna from Labuan fisher year 1993-2008 presented in (Figure 9). The catch of small pelagic was very high in 1994 (strong phase positive IOD *inphase* moderate El-Nino) as well as intensive upwelling (low SST and high cholophyll-a) and lower in phase negative dipole mode and La-Nina (high SST and low cholophyll-a). Different pattern showed by the catches of neritic tuna with high catch in phase negative IOD and La-Nina (high SST and low cholophyll-a) but lower inphase positive IOD and El-Nino (low SST and high cholophyll-a).

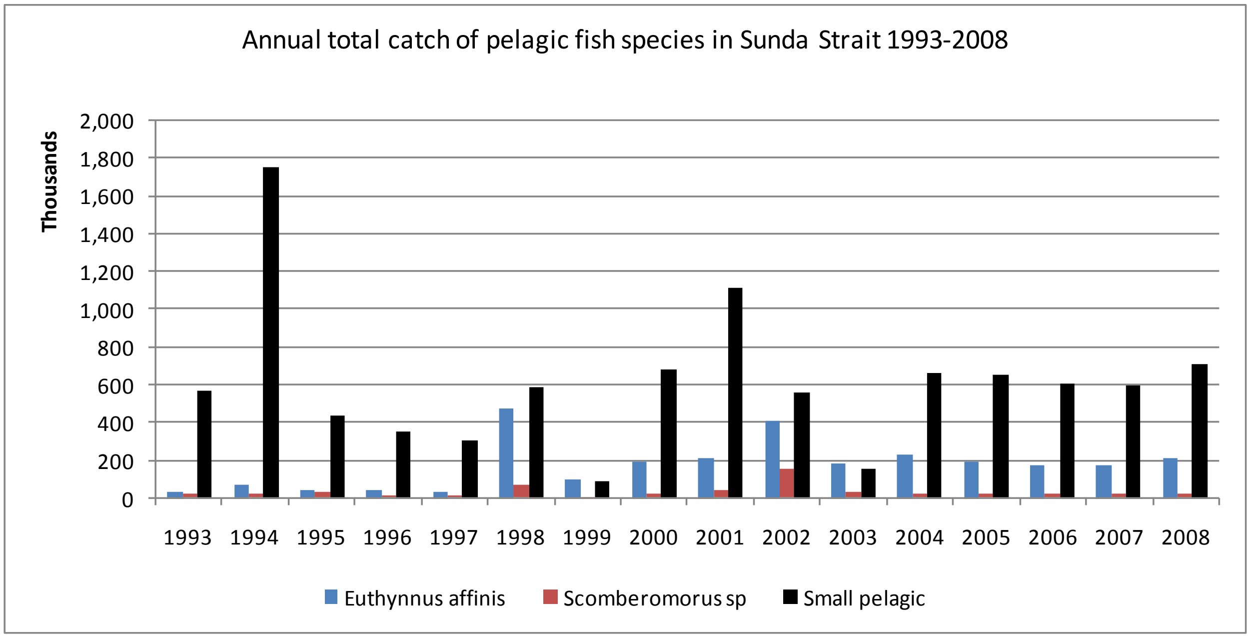
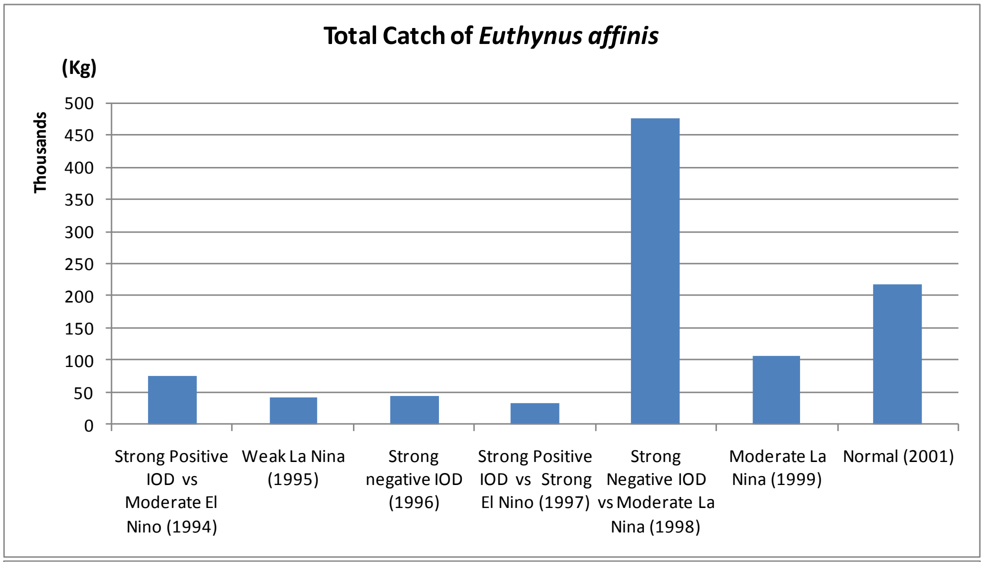


Figure 9. Annual total catch of small pelagic species and neritic tuna in Labuan,Sunda Strait 1993-2003

Figure 10 present the highest catch of *Euthynnus affinis* occur in phase strong negative IOD associated with moderate La-Nina (1998), followed by normal phase (2001) and moderate La-Nina phase (1999). Monthly catches fluctuation showed diferent pattern of inter phase.



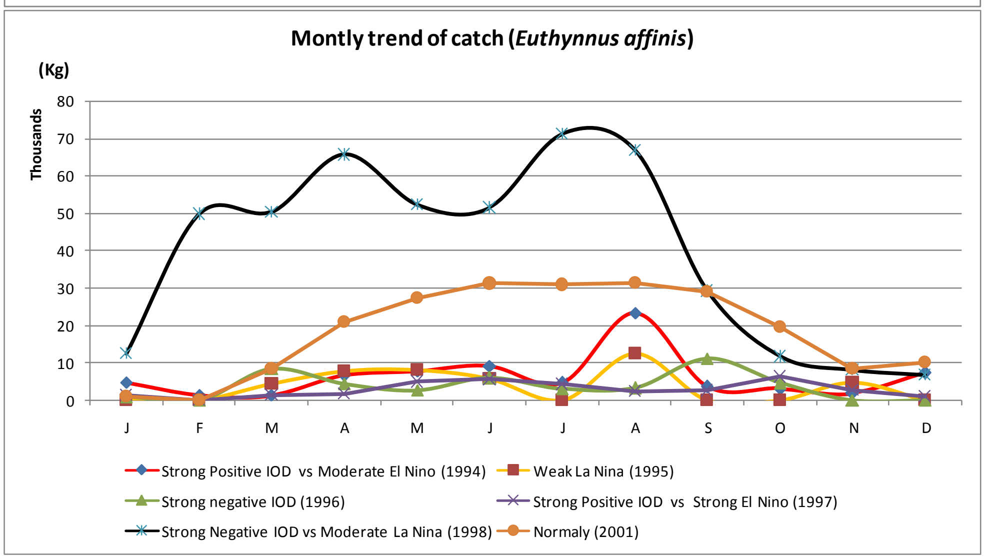


Figure 10: Annual total catch (above) and monthly fluctuation catch (below) of *Euthynnus affinis* in Labuan by phenomenon years.

The highest catch of *Scoromberomorus spp* also occur in strong negative IOD phase year 1996 and 1998, but low inphase positive dipole mode/El-Nino (Figure 11). There was a similar trend of monthly catches in 1996 and 1998 but different intensity whithin each month.

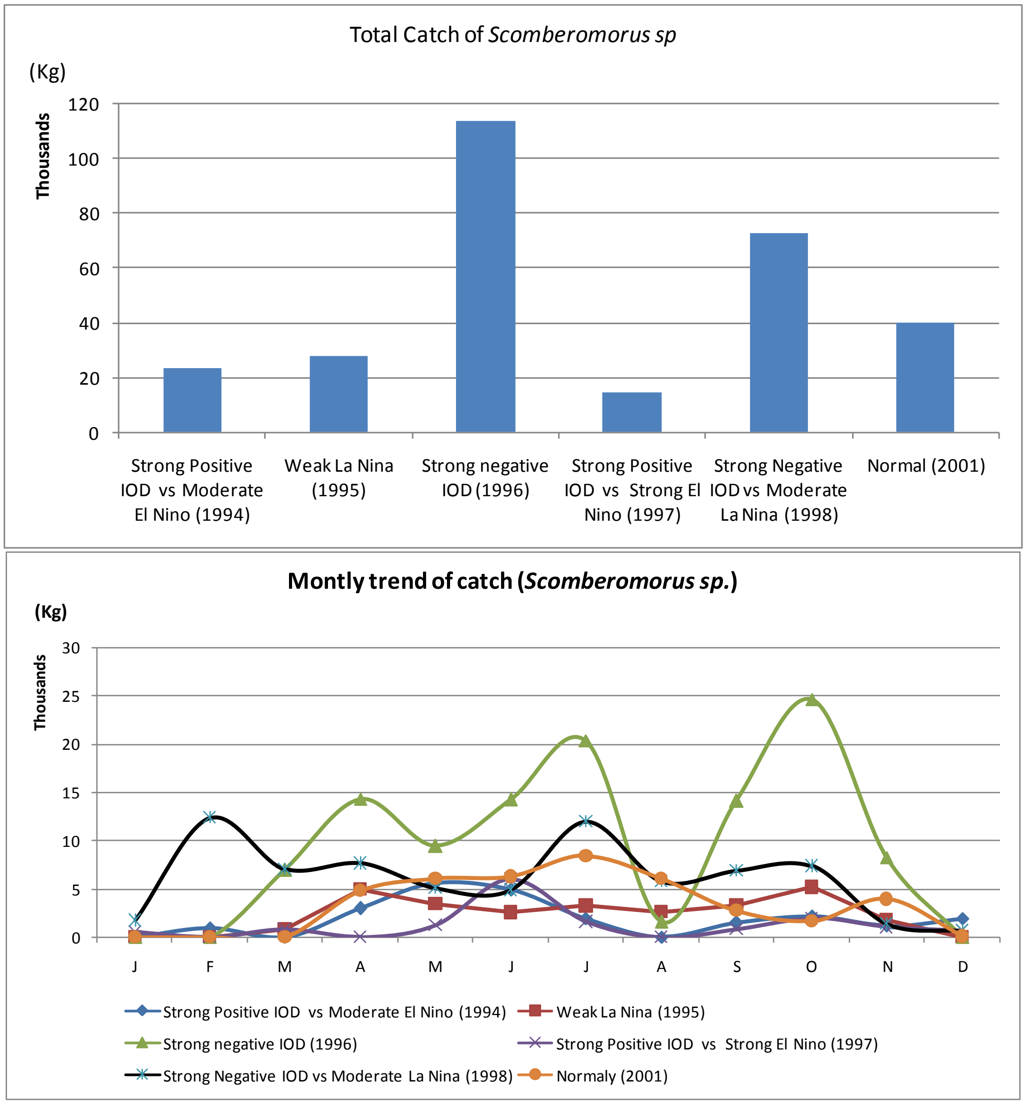


Figure 12: Annual total catch (above) and monthly fluctution catch (below) of *Scomberomorus comerson* in Labuan by years phenomenon

Different catch composition occur among dipole mode positive/El-Nino phase, dipole mode negatif/La-Nina phase and normal phase. Lowest catch proportion of tongkol (*Euthynnus affinis*) occur in dipole mode positive/El-Nino phase i.e. 8% (1994) and 9% (1997) while *Scoromberomorus sp* 1% (1994) and 4% (1997) (Figure 13). The highest catch proportion of tongkol (*Euthynnus affinis*) occur within dipole mode negative/La-Nina phase i.e 42% (1998) (strong negative IOD *inphase* moderate La-Nina) and 53% (1999) (moderate La-Nina) (Figure 14). In the normal phase the proportion of tongkol (*Euthynnus affinis*) was 16% (2001) (Figure 15).

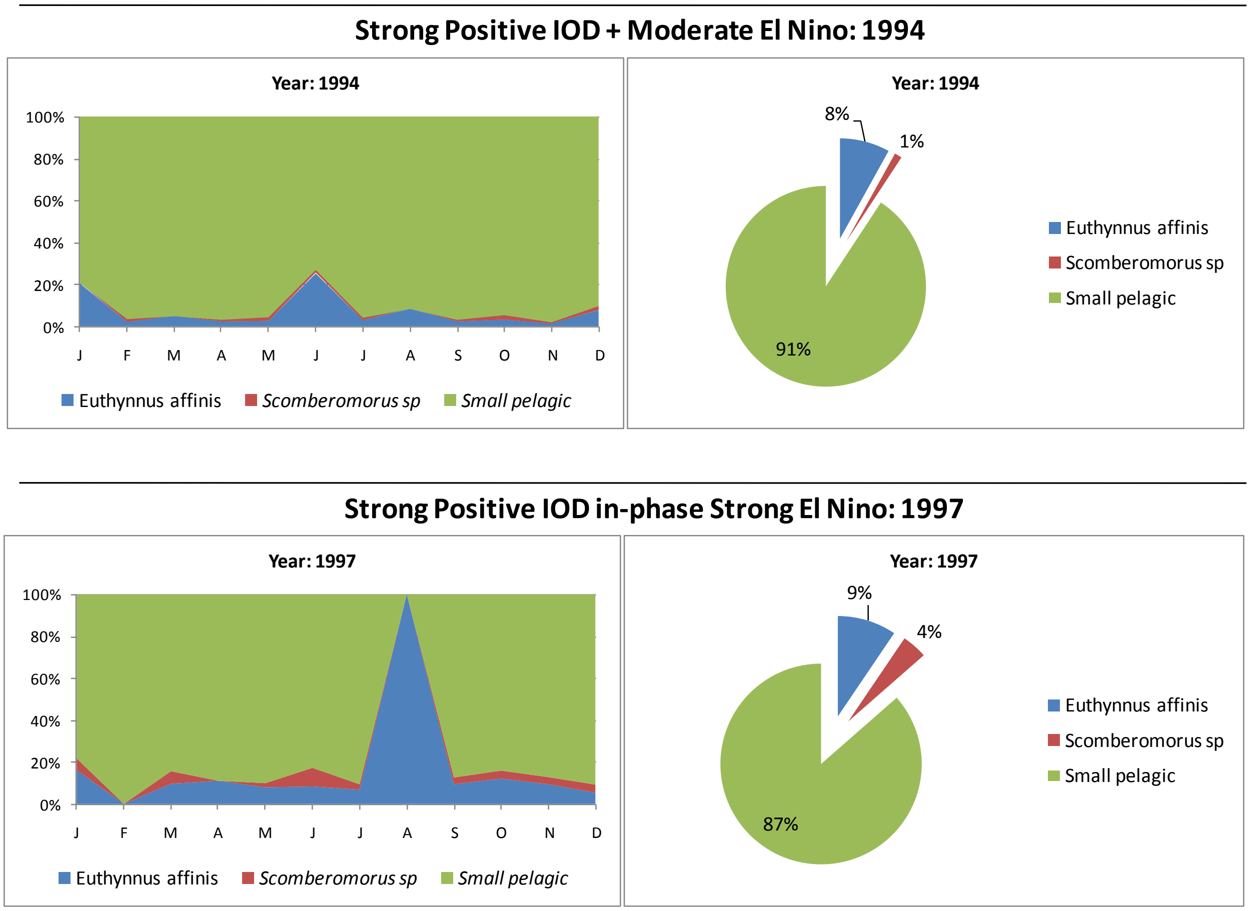


Figure 13:Catch composition of neritic tuna caught by mini purse seine in Labuan on Positive Dipole Mode and El-Nino event 1994 and 1997

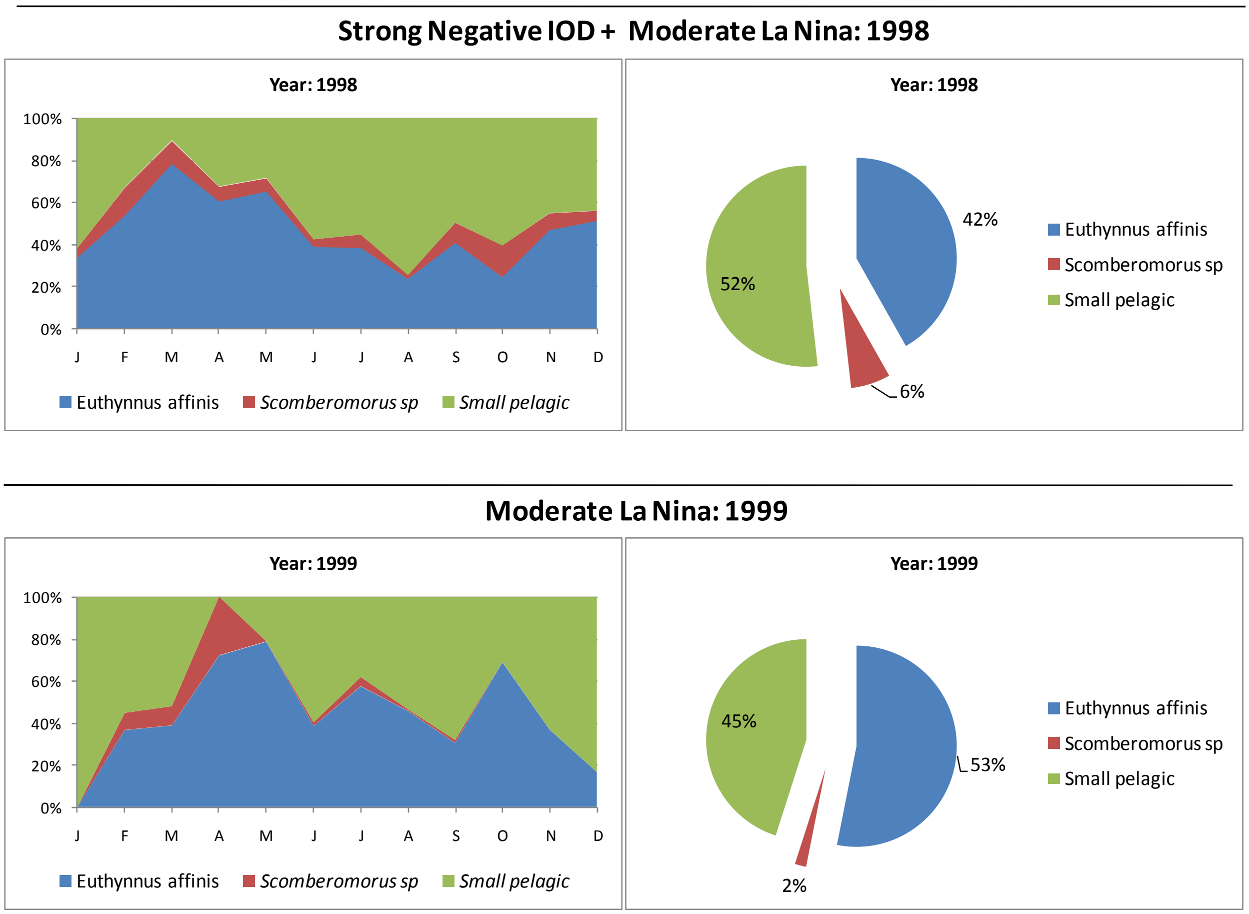


Figure 14: Catch composition of neritic tuna caught by mini purse seine in Labuan on Negative Dipole Mode and La-Nina event 1998 and 1999

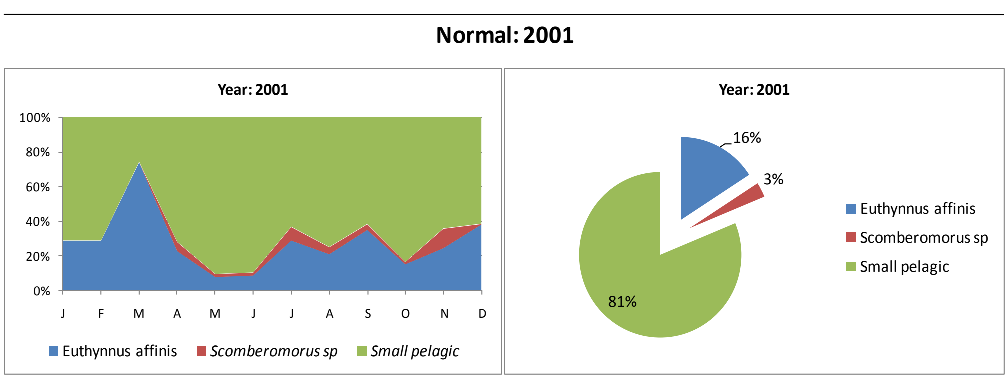


Figure 15: Catch composition of neritic tuna caught by mini purse seine in Labuan on Normal 2001

Table 3. Characteristic of neritic tuna (Euthynnus affinis) and ocean phenomenan by climate anomaly

Species	Climate Anomaly	Catch Characteristic	Catch Proportion	Ocean phenomena
Euthynnus affinis	Strong Positive IOD + Moderate El Nino (1994)	Minimum	Low (8%)	cold surface waters, high salinity and high nutrient (upwelling)
	Strong Positive IOD in-phase Strong El Nino (1997)	Minimum	Low (9%)	cold surface waters, high salinity and high nutrient (upwelling)
	Strong Negative IOD + Moderate La Nina (1998)	Maximum	High (42%)	warm surface waters, low salinity and low nutrient, surface waters transpor from rivers
	Moderate La-Nina (1999)	Maximum	High (55%)	warm surface waters, low salinity and low nutrient, surface waters transpor from rivers
	Normaly (2001)	Moderate	Moderate (16%)	moderately warm surface waters, and moderately low nutrient

Conclusion

1. Significance difference of SST distribution in the Sunda strait during regional climate anomaly occur i.e during positive dipole mode and during El-Nino the SST distribution tend low but higher and warm during in phase negative dipole mode or La-nina event
2. The catches of neritic tuna (*Euthynnus affinis)* in phase negative dipole mode or La-Nina was higher and dominate the catch composition of pelagic fishes of sunda strait. SST Distribution in this phase was higher and hence biologically the *Euthynnus affinis* have preference in warmer water might be making the species caught more from the water during this phase by the sunda strait fisher. Similar situation also showed by *Scomberomorus commerson* as a more coastal species.
3. Lower salinity resulted from high level of rain in phase negative dipole mode or La-Nina might be affecting the abundance of some neritic tunas in the sunda strait.

Sugestion and Outlook

Related to the data collected of the catches of neritic tuna from sunda straits and landed in PPP Labuan should recorded by gear and by species as well as fishing ground in order to have better accuracy and precision.

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APPENDIX

Table a. Monthly pelagic fish catch landing data in Labuan 1994-2003

SPECIES	Year: 1994 (kg)											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Euthynnus affinis	4803	1400	1273	6538	7808	9078	4550	23330	3518	3067	1832	7283
Scomberomorus comerson	0	983	0	2942	5620	4891	1967	0	1466	2200	1157	1933
Small pelagic	18354	61996	23863	271740	278378	257988	143194	250755	142671	89114	133655	83953
	Year: 1995											
Euthynnus affinis	0	0	4449	7800	8076	5789	0	12441	0	0	4622	0
Scomberomorus comerson	0	0	830	4950	3400	2559	3232	2607	3270	5149	1717	0
Small pelagic	0	0	18944	61750	73605	32337	65442	34127	53371	75072	28248	0
	Year: 1996											
Euthynnus affinis	880	0	8350	4330	2600	5934	2988	3205	11074	4622	0	0
Scomberomorus comerson	540	0	3030	1331	0	2192	2151	2200	3691	1861	0	0
Small pelagic	6967	1647	30873	32705	42650	64766	56464	38767	39991	39804	5054	0
	Year: 1997											
Euthynnus affinis	1400	0	1320	1750	4878	5573	4179	2339	2513	6225	2814	942
Scomberomorus comerson	480	0	820	0	1220	5971	1592	0	862	1970	1013	678
Small pelagic	6813	1123	11622	14145	55659	55732	56107	0	23462	43524	26174	16012
	Year: 1998											
Euthynnus affinis	12587	49793	50419	65697	52265	51448	71212	66742	29188	11682	8192	6786
Scomberomorus comerson	1712	12369	7035	7619	5093	4895	11954	5771	6922	7353	1400	646
Small pelagic	23101	30650	6782	35333	22786	76596	102962	213215	35657	29171	7919	5831
	Year: 1999											
Euthynnus affinis	0	1880	2397	1488	49439	12069	13478	8842	9323	4829	2123	450
Scomberomorus comerson	0	417	564	575	0	530	1008	138	426	0	0	0
Small pelagic	3543	2841	3223	0	13367	18773	8978	10396	20941	2173	3646	2263
	Year: 2000											
Euthynnus affinis	0	760	10834	8768	41661	38131	26008	13533	24521	18176	6847	3851
Scomberomorus comerson	0	0	0	0	0	4957	2188	6325	2522	811	641	2310
Small pelagic	621	1290	783.834	25802	62141	130567	106003	127759	129305	72895	20176	9747
	Year: 2001											
Euthynnus affinis	984	984	8438	20874	27332	31280	30890	31303	29,105	19,625	8477	10247
Scomberomorus comerson	0	0	0	4846	6074	6256	8424	6104	2716	1667	3943	76
Small pelagic	2460	2460	2947	66775	329461	335733	68333	113335	51619	110294	22525	16638
	Year: 2002											
Euthynnus affinis	8864	2445	33879	51462	39888	45017	48649	38030	42181	41872	36644	23183
Scomberomorus comerson	0	0	3725	27780	27437	21583	21952	31336	1986	6528	6753	1613
Small pelagic	1103	1247	4755	100614	164730	94549	93092	51509	6738	12566	20136	9760
	Year: 2003											
Euthynnus affinis	18433	8457	16109	35351	29238	38313	12897	27762				
Scomberomorus comerson	1642	1429	2408	6436	4365	6719	7992	1569				
Small pelagic	8074	2160	2893	34991	46806	34180	27715	5836				

Table b. Total Catch of Pelagic Fish Species in Labuan 1993-2008

SPECIES	YEARS							
	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Euthynnus affinis	35853	74480	43177	43983	33933	476011	106318	193090
Scomberomorus comerson	26510	23159	27714	16996	14606	72769	3658	19754
Small pelagic	569666	1755661	442896	359688	310373	590003	90144	687089.83

SPECIES	YEARS							
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Euthynnus affinis	218555	412114	186560	238350	192560	182560	178700	214170
Scomberomorus comerson	40106	150693	32560	17879	18218	21218	19228	19176
Small pelagic	1120120	560799	162655	668880	657580	611740	599380	716830