The Size and The Shape of Sagittal Otolith of Redtail Scad, *Decapterus kurroides* Blekeer 1855 from Kema Bay, North Minahasa Regency, North Sulawesi, Indonesia

Fransine B. Manginsela[1]*, Gybert E. Mamuaya[1], Rizald M. Rompas[1], and Lawrence J. L. Lumingas[2]

[1] *Post Graduate Marine Science, Fisheries and Marine Science Faculty, Sam Ratulangi University*
[2] *Water Resources Management, Fisheries and Marine Science Faculty, Sam Ratulangi University*
Kampus Unsrat Bahu, Manado 95115

*Corresponding author: manginsela_fransine59@yahoo.com

ABSTRACT

This study aimed to examine the difference in the otolith size and otolith shape of redtail scad *Decapterus kurrodes* between sex in North Sulawesi. The otoliths of *D. kurroides* were studied for sagitta otolith pair samples of 34 juveniles, 58 females and 75 males from Kema Bay. These pairs sagitta otolith images were interpreted using ImageJ tool to describe the otolith size (length, width, perimeter, and area), then we calculated the shape index (form factor, roundness, circularity, rectangularity, ellipticity and aspect ratio or length-width ratio). No significant difference was found in otolith length between left and right otoliths of juveniles of *D. kurroides* or called symmetrical but significant differences or asymmetrical were found in all sample, females and males. The regressions of total length against otolith sizes (otolith lengt, otolith width otolith perimeter and otolith area of *D. kurroides* follow a power function. The growth patterns showed dominant allometric growth in total length–otolith sizes relationships of *D. kurroides* from Kema Bay.

Keywords: size, shape index, otolith, *Decapterus kurroides*, Kema Bay.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui perbedaan ukuran dan bentuk otolit ikan layang anggur, *Decapterus kurroides* antar jenis kelamin di Sulawesi Utara. Otolit dari *D. kurroides* dipelajari untuk sampel pasangan sagitta otolit dari juvenil sebanyak 34 individu, betina sebanyak 58 individu dan jantan sebanyak 75 individu dari Teluk Kema. Citra pasangan otolit sagitta ini diinterpretasikan menggunakan fasilitas gambar untuk mendeskripsikan ukuran otolit (panjang, lebar, keliling, dan luas), kemudian dihitung indeks bentuk otolitnya (faktor bentuk, kebulatan, sirkularitas, persegi panjang, elips dan rasio aspek atau rasio panjang-lebar). Tidak ditemukan perbedaan yang signifikan pada ukuran dan indeks bentuk otolit antara otolit kiri dan kanan dari juvenile, *D. kurroides* atau disebut juga simetris. Sebaliknya signifikan atau asimetris ditemukan pada semua sampel otolit betina dan jantan. Regresi panjang total terhadap ukuran otolit (panjang otolit, lebar otolith perimeter, dan luas otolit) *D. kurroides* mengikuti fungsi perpangkatan (multiplikatif). Pola pertumbuhan menunjukkan pertumbuhan alometrik dominan dalam hubungan panjang total dengan ukuran otolit *D. Kurroides* dari Teluk Kema.

Kata kunci: size, Bentuk Indeks, otolith, *Decapterus kurroides*, Teluk Kema.

1. Introduction

Fish is one of the water resources contributing protein to human life, this commodity can be eaten by various levels of human life and so all religions do not forbid him to eat. Redtail scad, *Decapterus* kurroides as a small pelagic fish known locally as 'malalugis anggur', this fish is not only consumed by humans but are useful as bait fish in catching tuna and skipjack. Scad fish production in Indonesia is high and with a wide market share, including in this area. The economic value is generally in the medium price category (Sumaila *et al.* 2007). Redtail scad is a fish which has prominent red colour on the tail and is in one genus with other red-tailed scads, such as *D. akaadsi, D. tabl and D. smithvanizi* n. sp. (Kimura *et al*, 2013) It is called *Decapterus* that comes from the word deca = ten and pteron = finlet (Rumero 2002). The fish is categorized in class Actinopterygii, order Perciformes, sub-order Percoidei and family Carangidae (Masuda *et al.*, 1975, 1984; World Registered Marine SpeciesWORMS: http://www.marinespecies.org/aphia.php?p= sourcedetails&id=234250) and *fishbase* (https://www.fishbase.se/search.php).

Biologically in fish found ear stones (otolith), functions as a hearing aid and regulates body balance. In its development, otolith is also used as a very useful tool for determining fish age and growth. Even Begg and Brown (2000) can also be used to identify stocks. Otolith is part of the inner ear of fish including scad fish.

The otolith study on various marine fishes in tropical regions, especially Indonesia, has not been significantly conducted. Wright *et al* (1990) have firstly reported it on *Stolephorus heterolobus* in Java Sea, then on several species of eels (*Anguilla* spp.) around Sulawesi waters and others (Arai *et al.* 2000, 2003; Sugeha et al 2001; Kuroki *et al.* 2005; Lee et al 2008; Chino & Arai 2010), bluefin tuna (*Thunnus maccoyii*) around Bali waters (Shiao *et al.* 2009; William *et al.* 2013; Farley *et al.* 2014), Chinese herring (*Tenualosa toil*) around Sumatera waters (Milton & Cheney 2001), red snapper (*Lutjanus erythropterus*) around Nusa Tenggara waters (Fry & Milton 2009), Bali sardinella (*Sardinella lemuru*) around Bali waters (Wujdi *et al.* 2016), skipjack tuna (*Katsuwonus pelamis*) in the southern waters of Java and the Sulawesi Sea (Wujdi *et al.* 2017, 2018; Mogea *et al.* 2019), and *Selar crumenophthalmus* in Manado Bay (Bahri *et al.* 2018). Otolith study does not merely aim to get information on fish aging and fish growth but also to identify or discriminate the fish stock. According to Campana & Casselman (1993), the size and the shape of otolith are also beneficial to use as stock identity indicator for varied growth rate among fish stocks. This study aimed to characterized otolith and examine the difference in the otolith size and otolith shape of redtail scad *Decapterus kurrodes* between juvenile, male dan female from Kema Bay, North Sulawesi.

2. Materials And Methods

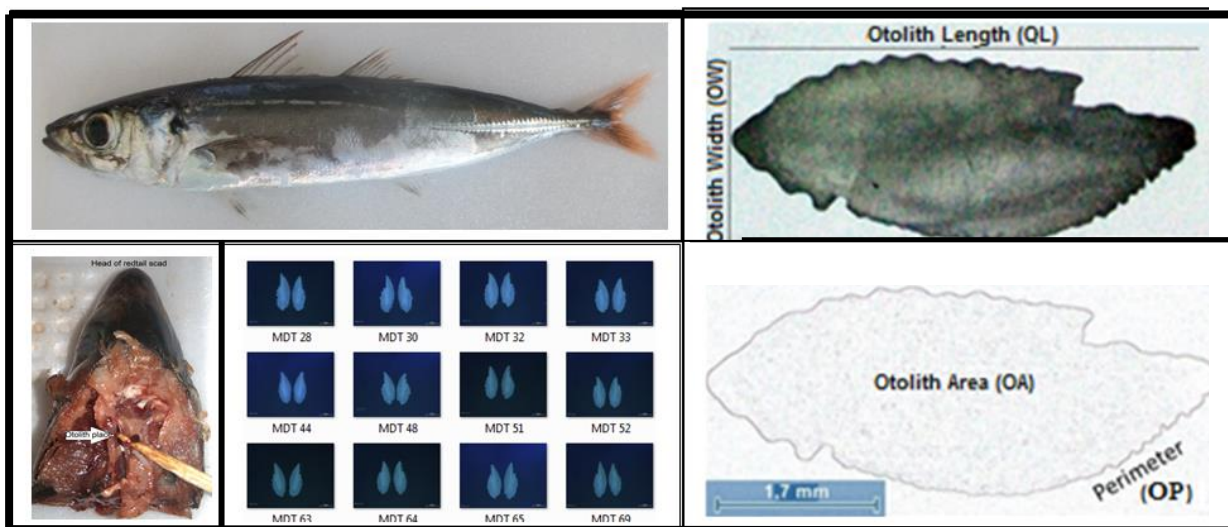**Figure 1**. Research location of Kema Bay, North Sulawesi

Figure 2. Redtail scad *Decapterus kurroides*, head place of otolith, otolith image and otolith size OL = length, OW = width, OP = perimeter and OA = .Area

This study was carried out from September 2017 to September 2019. Redtail scads *D. kurroides* were obtained from fishermen's catches in Kema Bay (Geographical 1°15 '-1°22' North / 125°05'-125°15' East) (Figure 1). The fish were caught with vertical multiple hook-handline and mini purse seine. They were proportionally taken to represent the exploited fish body size. Data collected included sex and total length (TL). The redtail scad that were used as the research sample consisted of 167 individuals, measuring a total length with an average of 159 mm with total length an interval of 97 mm-203 mm. Redtail scad are then taken to the Laboratory of Fish Health and Fish Health, Environment, and Toxicology of FPIK UNSRAT. Redtail scad ascertaining their sexes by observing their gonads. The head is then separated and the otolith will then be taken out from just below the skull near the spine. Otolith is cleaned with H_2O_2 to dissolve the blood, and then washed with deoionized water (WaterOne) then air dried using 70 % alcohol. The otoliths to be observed under a stereo microscope Olympus SZX7-DP21 microscope camera, the pair of left and right otoliths documented into photographic image. The image of an otolith is used by the imageJ facility to obtain the size of the otolith, in 4 parameters, length (OL), width (OW), perimeter (OP) and area/breadth (OA), here in after shall be referred to as otolith size as presented in Figure 2. The shape index

calculation includes the roundness index and the aspect ratio.

There were 6 parameters of the shape indices calculated from the size of the otolith ((Wujdi et al 2016; Ladroit et al 2017), form-factor (FF) = $(4\pi AO)/OP^2$, roundness (RO) = $(4OA)/(\Pi OL^2)$, circularity (CI) = OP^2/OA, rectangularity (RE) = $OA/(OL*OW)$, ellipticity (EL) = OL- OW/OL + OW and aspect ratio (AR) = OL/OW. Difference in otolith size and shape index between the left and the right ones was analyzed using pair t-test, while the difference in the otolith size and shape between sex was tested with t-test. The relationship of otolith size against the fish TL was estimated using equation $Y = a X^b$, where Y is otolith size (OL and OW) and X is fish total length (TL), a is intercept, and b is slope. Parameters a and b were calculated using Least Squares method after the data had been transformed to natural logarithm as ln Y = ln a + b ln X. The linearity and the goodness of fit were analyzed using ANOVA, whereas the regression line comparison used analysis of covariance (ANCOVA) (Scherrer 1984; Draper & Smith 1998). To examine whether b equals to the theoretical value of b = 1 (for the relationship of OL and OW), t-test was applied. If $t_{calc.}$ is bigger than $t_{tab.}$, the growth pattern is allometric or the otolith growth increment does not go along with the body length increment whereas if it is the opposite, the growth pattern is isometric or the otolith size increment is in line with the body

Table 1. T-test comparison of mean pairs (left-right) of size and shape index of total pairs sampel otolith redtail scad, *Decapterus kurroides* from Kema Bay.

Otolith size and shape index	Total Sampel (n = 167)			
	Left	Right	t_{cal}.	$t_{tab (0.05, 165)}$.
Otolith Size				
Otolith length OL (mm)	4.146	4.137	2.308*	1.967
Otolit width OW (mm)	1.758	1.742	5.257*	1.967
Otolith perimeter OL (mm)	11.232	11.207	0.912 ns	1.967
Otolith area OA (mm²)	4.990	4.965	4.842*	1.967
Otolith shape index				
Form Factor FF	0.490	0.489	0.449 ns	1.967
Roundness RS	0.362	0.363	-0.531 ns	1.967
Circularity CI	25.777	25.828	0.445 ns	1.967
Rectangulariry RE	0.668	0.672	-3.152*	1.967
Ellipsticity EL	0.403	0.405	-2.148*	1.967
Aspek Nisbah AR	2.352	2.365	-2.102*	1.967

Note: ns = not significant, s = significant

length increment. Similar to the comparisons of otolith morphometric parameters between sexes, the relationships of otolith size (length,width, perimeter and area) with total length of fishes were determined using left otolith values for all individuals.

3. Results and Discussions

3.1 Total length of fish.

The redtail scad that were used as the research sample consisted of 167individuals, measuring a total length with an average of 159 mm with total length an interval of 97 mm-203 mm. The fish samples were then grouped into three groups, juveniles, females and males. There are 34 juvenile fish with average: 110 mm (range 97-136 mm), 58 females average 175 mm (range 151-199 mm) and 75 males average 169 mm (range 126-203 mm). Comparison of two samples with t-test for total length of fish (TL) just males and females. There are significant differences (assuming variance is not the same) between female scad compared to male scad (female vs male) (t_{cal} = 37.064 and P = 0.000).

The sample size of this fish is smaller than the average length of redtail scad caught as reported by fishbase which is at common

Table 2. T-test comparison of the average left-right paired samples of the size and shape index of juveniles, females and males redtail scad otoliths, *Decapterus kurroides*

Otolith size and shape index	Juvenile n = 34			Female n = 58			Male n = 75		
	Left	Right	t_{cal}.	Left	Right	t_{cal}	Left	Right	t_{cal}
Otolith size									
OL (mm)	2.932	2.927	0.663 ns	4.554	4.514	2.431*	4.383	4.376	0.661 ns
OW (mm)	1.328	1.321	1.389 ns	1.896	1.877	4.400*	1.841	1.824	3.312 s
OP (mm)	7.998	7.967	1.001 ns	12.294	12.236	0.980 ns	11.829	11.832	-0.077 ns
OA (mm²)	2.596	2.586	1.647 ns	5.774	5.707	5.105*	5.436	5.414	1.861 ns
Otolith shape index									
FF	0.511	0.513	0.550 ns	0.482	0.480	0.232 ns	0.487	0.485	0.619 ns
RS	0.384	0.384	0.004 ns	0.355	0.357	0.856 ns	0.359	0.359	0.959 ns
CI	24.699	24.60	0.614 ns	26.270	26.270	0.262 ns	25.917	24.719	0.693*
RE	0.665	0.668	0.929 ns	0.669	0.673	2,272*	0.669	0.675	-2.162*
EL	0.376	0.377	0.869 ns	0.412	0.412	0.267 ns	0.407	0.411	-2,632*
AR	2.207	2.214	0.815 ns	2.403	2.406	0.220 ns	2.379	2.399	-2,632*

Note: ns = Not significant, * = significant

total length 30 cm and can reach a maximum size of 45 cm. In the Masuda *et al.* (1975, 1984) report, it was mentioned that there were male fish capable of reaching a maximum TL of 300 mm even 400 mm. Information on the size of this mature sex fish is not yet available in fishbase but Maulita *et al.* (2013) reported that the male scad maturity is at 32 cm and 33 cm on female. This research was able to distinguish females and males by checking at their gonads. Females at the smallest size were 175 mm while males at the smallest size were 151 mm. Thus, were smaller than the size of the first mature gonads that have been reported.

3.2 The otolith size and shape index of redtail scad

The total number of intact otolith samples collected was 167 pairs. Range of otolith length left- right: 2.523 mm – 5.259 mm and 2.517 mm - 5.173 mm, mean of otolith length left- right: 4.146 mm and 4.137 mm are small otolith (Furlani *et al.*, 2007). Range of otolith width left and right: 1.150 mm – 2.078 mm and 1.153 mm – 2.089 mm, otolith perimeter (OP): left and right: 6.910 mm-13.926 and 6.108 mm - 14.312mm and left otolith (OA) area 2.170 mm - 6.954 mm and right 2.215 mm – 6.966 mm. The analysis of the shape indeces of the otolith form factor has been calculated that were the form factor (FF) left and right : 0.401 - 0.567 and 0.385-0.50 or FF < 1 which **s**hows scad otolith is

circular, roundness (RS) left the right : 0.304 - 0.420 and 0.318-0.422 or RS < 1 indicates that the otolith is not round, circularity (CS), Rectangularity (RE) left and right : 0.634 - 0.703 and 0.619 - 0.796 : and Ellipsticity (EL) left and right : 0.334 - 0.45 and 0.347 - 0.46 and the aspect ratio of left AR : 2.004-2.808 and right AR 2.065 – 2.816 or AR > 1 indicates the otolith is not square (AR = 1) but is elongated. All otolith size and shape indices show no real difference between left and right side ($t_{cal} < t_{tab\,(0.05,\,165)}$) (Table 1). Comparison of size and shape index of otolith pairs redtail scad otoliths to characterize or differentiate otolith. Table 1. calculation of t-test for the mean comparison of all left-right paired otolith samples redtail scad turned out to be not significantly different ($t_{cal} < t_{(00.5,\,n-2)}$) on otolith perimeter, form factor, roundness and circularity or there was difference between the left and right otolith ($t_{cal} > t_{(00.5,\,n-2)}$) on otolith length, otolith width and otolith area, thus it could be said that left otolith and right otoliths were asymmetrical.

The comparison of otolith pairs (left and right side) is also done by doing the same grouping of juveniles (34 ind), females (58 ind) and males (75 ind) as presented in Table 2. Calculation of t-test for the average comparison of all left-right paired otolith samples redtail scad both on the size and on the shape index turned out to be not significant ($t < t_{(00.5,\,n-2)}$) on juvenils otolith pairs was symmetrical. But there was

Table 3. T-test comparison of mean male-female of the otolith size and shape index of the redtail scad *Decapterus kurroides*

Otolith Size and Shape Index	Females n = 58				Males n = 75				t_{cal}	$t_{(00.5,\,n-2)}$
Size	Min	Max	Var	Mean	Min	Max	Var	Mean		
Otolith Length (OL) mm	4.040	5.259	0.064	4.554	3.134	5.173	0.193	4.383	2.613*	1.979
Otolith Width (OW) mm	1.669	2.023	1.005	1.896	1.373	2.078	0.023	1.841	2.543*	1.979
Otolith Perimeter (OL) mm	10.906	13.926	0.620	12.294	8.798	13.882	1.430	11. 829	2.564*	1.979
Otolith Area (OA) mm	4.555	6.799	0.187	5.774	3.051	6.954	0.761	5.436	2.710*	1.979
Shape Index										
Form Factor (FF)	0.411	0.558	0.001	0.482	0.401	0.567	0.001	0.487	-0.879[ns]	1.979
Roundness (RS)	0.304	0.408	0.000	0.355	0.314	0.407	0.000	0.359	1.134 [ns]	1.979
Circularity (CS)	22.529	30.594	3.598	26.209	22.174	31.321	3.206	25.91	0.909 [ns]	1.979
Rectangulariry RE	0.304	0.408	0.000	0.355	0.634	0.703	0.000	0.669	0.267 [ns]	1.979
Ellipsticity EL	0.362	0.464	0.000	0.412	0.363	0.453	o.ooo	0.407	1.149 [ns]	1.979
Aspect Ratio (AR)	2,134	2.808	0.014	2.403	2.141	2.101	0.015	1.129	1.126 [ns]	1.979

Table 4. Relationship of total length (TL) and Otolith size (OL = Otolith Length, OW = Otolith Width, OP = Otolith Perimeter and OA = Otolith Area) of of the redtail scad *Decapterus kurroides*

| Model | n | r | R^2 | Anova | | | Uji – t | | |
| | | | | Model | | | [1]b teoritis = 1; [2] b = 2 | | |
				F ratio	nilai P	s_b	t	t-tab	Pattern
ln(OL) = 3.261 + 0.923*ln(k TL)	167	0.96	92.305	1979.36	0.000	0.021	3.667*	1.974	Allometri
ln(OW) = 3.22 + 0.746*ln(k TL)	167	0.96	92.950	2175.35	0.000	0.081	3.136*	1.974	Allometri
ln(OP) = -2.194 + 0.909*ln(k TL)	167	0.96	91.484	1772.70	0.000	0.022	2.252*	1.974	Allometri
ln(OA) = 6.927 + 1.678*ln(k TL)	167	0.97	94.951	3102.70	0.000	0.152	4.134*	1.974	Allometri

Note : [1]b=1 at OL, OW and OP; [2]b=2 at OA; s_b = standar erorr b; * = significant; [n] = no significant

difference between the left and right otolith on female and male otolith pair thus it could be said that left otolith and right otoliths were asymmetrical.

Otolith pairs of juvenile redtail scad was symmetrical. Wujdi *et al.* (2016) stated there was no real difference between the size of the left and right otolith or symmetrical of lemuru fish (*Sardinela lemuru*) in the Bali Strait, as well as for anchovy (*Engraulis encrasicolus*) in Black and Marmara Sea (Zengin *et al.* 2015), Scad

(*Decapterus muroadsi)* in the Kema Bay of North Sulawesi (Manginsela *et al.* 2017), *Decapterus muroadsi* scad in Manado Bay (Umar *et al.* 2019), *Selar crumenopthalmus* from Kema Bay (Mamuaya *et al.* 2017a and Taliawo *et al.* 2018), Cakalang (*Katsuwonus pelamis*) in Bitung (Mamuaya *et al.* 2017b) and in Manado (Mogea *et al.* 2019). Otherwise, otolith pairs of female and male difference size or asymetrical like otolith of plaice *Pleuronectes platessa* and turbot, *Psetta maxima* (Helling et al. 2005).
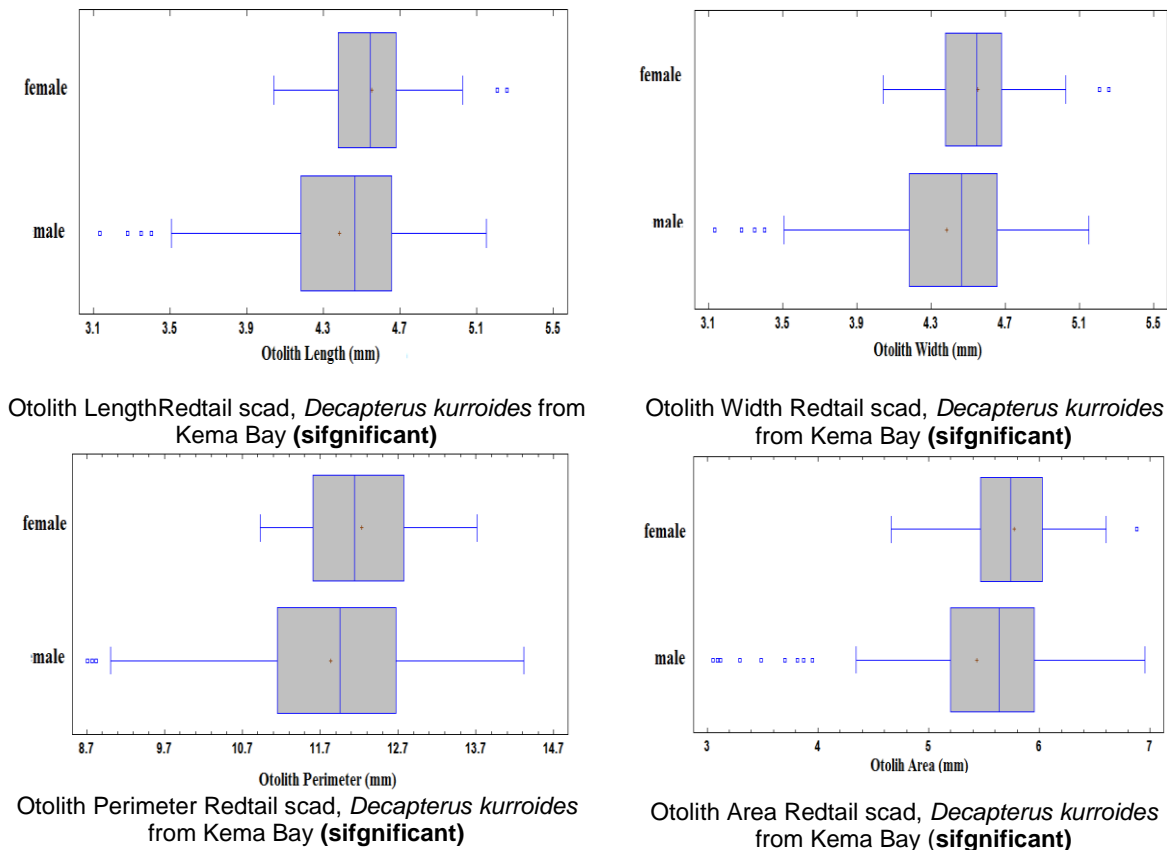

Otolith LengthRedtail scad, *Decapterus kurroides* from Kema Bay **(sifgnificant)**

Otolith Width Redtail scad, *Decapterus kurroides* from Kema Bay **(sifgnificant)**

Otolith Perimeter Redtail scad, *Decapterus kurroides* from Kema Bay **(sifgnificant)**

Otolith Area Redtail scad, *Decapterus kurroides* from Kema Bay (**sifgnificant**)

Figure 3. Box and Whisker plot of comparison female and male otolith size of redtail scad *Decapterus kurroides* from Kema Bay

Table 5. Total length (TL) regression relationships - sagitta otolith measurements (OL = Otolith Length, OW = Otolith Width, OP = Otolith Perimeter and OA = Otolith Area) of juveniles, females and male redtail scad *Decapterus kurroides*

Model	n	r	Anova					Uji – t			
			Model		Lack of fit			*b = 1; ** b = 2			
			ratio F	nilai P	Ratio F	nilai P	s_b	t-hit	t-tab	Pattern
Juvenile										
ln OL = -3.114 + 0.891*ln(TL)	34	0.80	58.37	0.000	1.040	0.462	0.117	0.932	2.037	Isometri
ln(OW) = -2.239 + 0.536*ln(TL)	34	0.66	24.88	0.000	1.450	0.231	0.108	4.296*	2.037	Allometri
ln(OP) = -2.743 + 1.025*ln(TL)	34	0.84	75.03	0.000	0.960	0.525	0.118	0.212	2.037	Isometri
ln(OA) = -5.438 + 1.358*ln(TL)	34	0.77	46.64	0.000	1.210	0.348	0.199	3.226*	2.037	Allometri
Female										
ln(OL) = -1.943 + 0.669*ln(TL)	58	0.58	28.93	0.000	0.950	0.547	0.124	2.669*	2.003	Allometri
ln(OW) = -1.483 + 0.410*ln(TL)	58	0.54	23.47	0.000	1.630	0.099	0.085	6.929*	2.003	Allometri
ln(OP) = -1.231 + 0.723*ln(TL)	58	0.54	23.63	0.000	0.940	0.555	0.149	1.872	2.003	Isometri
ln(OA) = -3.629 + 1.041*ln(TL)	58	0.67	45.62	0.000	0.970	0.522	0.154	6.227*	2.003	Allometri
Male										
ln(OL) = -2.887 + 0.850*ln(TL)	75	0.82	160.93	0.000	1.510	0.109	0.067	2.239*	1.993	Allometri
ln(OW) = -3.139 + 0.731*ln(TL)	75	0.87	225.29	0.000	1.820	0.369	0.049	5.490*	1.993	Allometri
ln(OP) = -1.900 + 0.851*ln(kTL)	75	0.83	166.88	0.000	1.130	0.355	0.066	2.258*	1.993	Allometri
ln(OA) = -6.439 + 1.583*ln(kTL)	75	0.89	287.30	0.000	2.26	0.078	0.093	4.484*	1.993	Allometri

Note: sb = standard error b

There was significant difference in ratio between the left otolith and right otolith, therefore the analysis was carried out using only the left side consistently in the *t*-test of male and female samples on otolith size and shape index in male and female fish. The results that differed from the results of the *t*-test comparison mean of male and female presented in Table 3 turned out to be the size of the otolith OL, OW, OP and OA all significantly different are presented in Figure 3 (t > $t_{(0.05, 167-2)}$). In contrast, the shape index CS, RS and AR were not significantly different (t < $t_{(0.05, 165)}$). It can be said that between males and females, there were no difference in the shape index between males and females.

Table 6. ANOVA of regression line of– ln(TL)-ln (Otolith size) of *D. kurroides* from Kema Bay

Size	Sample	ANOVA			
		Intercept (a)		Slope (b)	
		F-ratio	P-value	F-ratio	P-value
ln(TL) - ln(OL)	Female and Males of *D. kurroides* from Kema Bay	1.030	0.311[ns]	2.230	0.137[ns]
ln(TL) - ln(OW)	Female and Males of *D. kurroides* from Kema Bay	0.340	0.561[ns]	7.79	0.006[**]
ln(TL) - ln(OP)	Female and Males of *D. kurroides* from Kema Bay	0.610	0.434[ns]	0.570	0.450[ns]
ln(TL) - ln(OA)	Female and Males of *D. kurroides* from Kema Bay	0.790	0.377[ns]	6.250	0.014[*]

Notes: TL = Total Length, OL = Otolith Length, OW = Otolith Width OP = Otolith Perimeter, OA = Otolith Area, ns = not significant, * = significant; ** = highly significant.
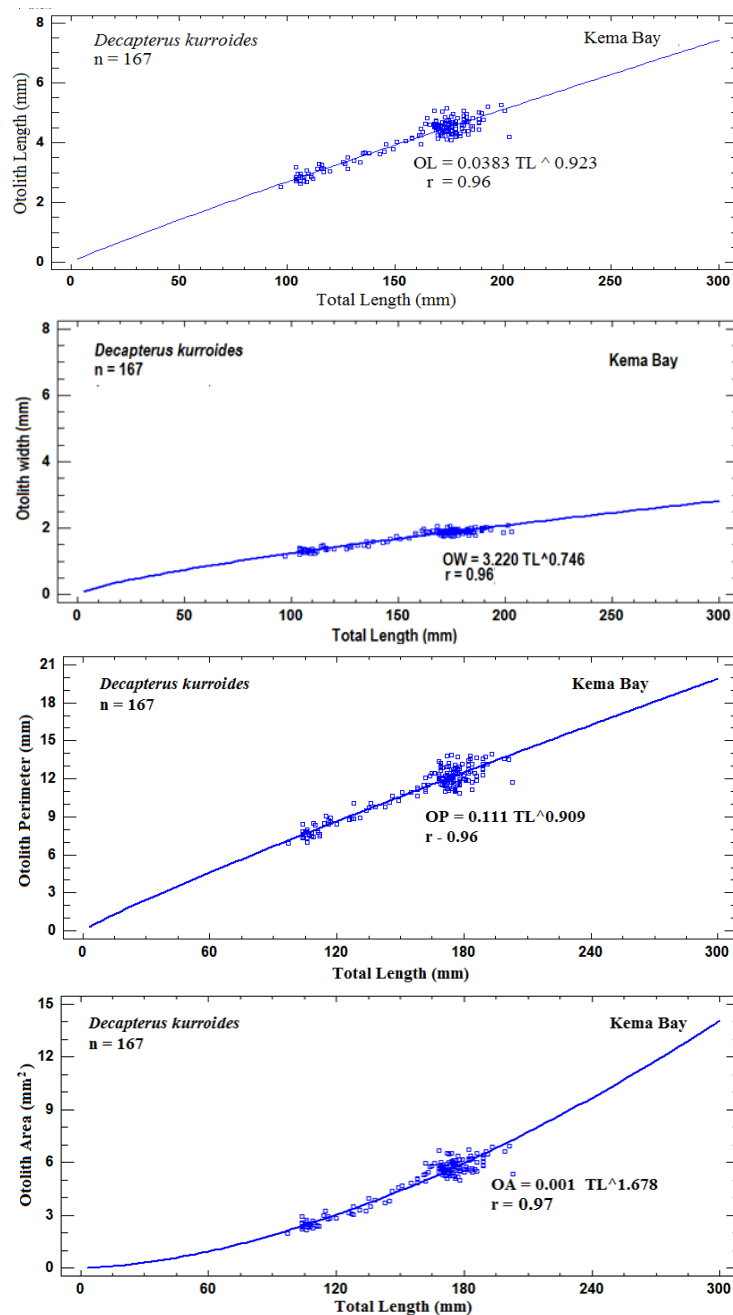
Figure 4. The power model of TL-OL, TL-OW, TL-OP and TL-OA relationship of *Decapterus kurroides* from Kema Bay.

Both the average CS female = 0.482 and the average CS male = 0.487; CS <1 showed that the scad otolith is not round. Likewise, the mean female RS (0.355) and the average female RS (0.359), both RS <1 shown that the otolith scad are not round. While the gene and regulative protein responsible for the peripheral biomineralisation process have been identified, it remains unclear how the symmetry between the right and left otoliths in fish species is
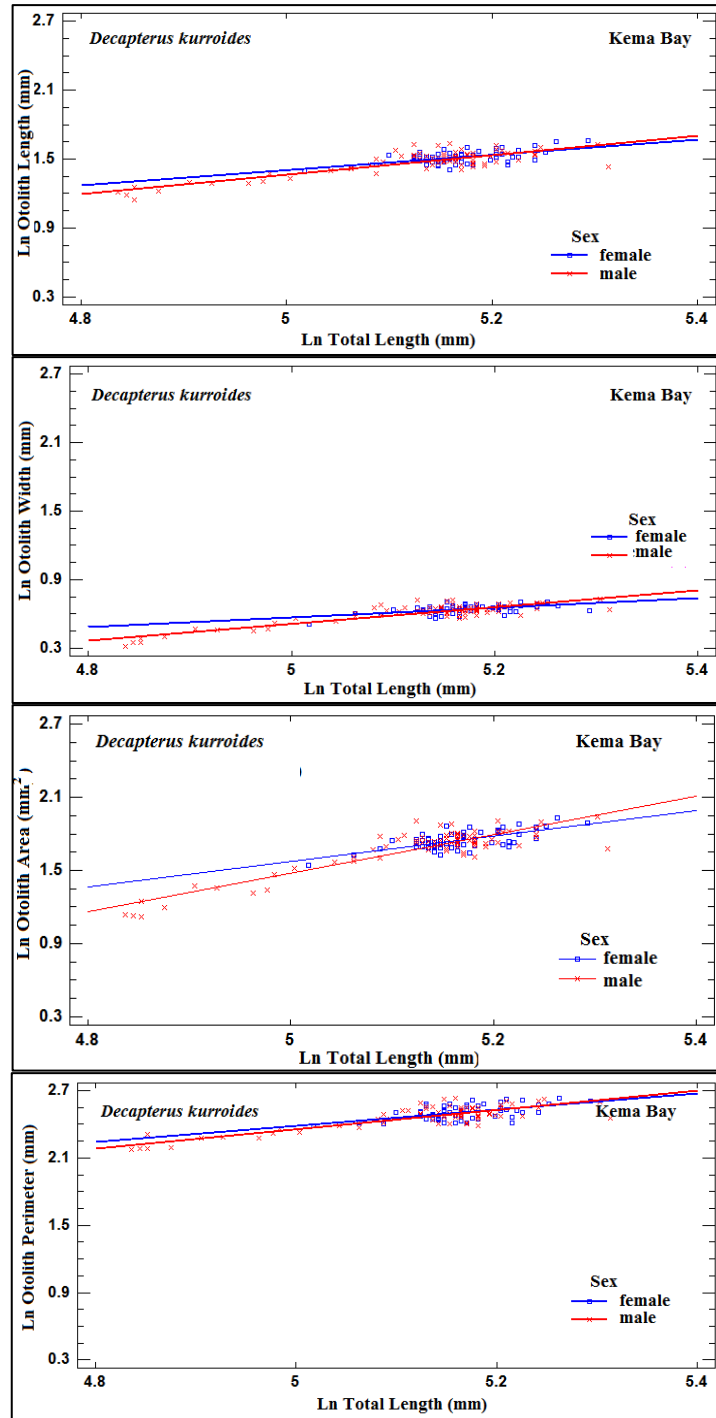
Figure 5. Regression line comparison of Ln TL- Ln OL, Ln TL- Ln OW, Ln TL- Ln OP and Ln TL- Ln OA of *D. kurroides* from Kema Bay.

regulated.Average male AR = 2.134) and female AR mean = 1.129 are both AR > 1 shown elongated otolith scad. The form of otolith was specific to each species was given a name. Specifically, redtail scad otolith that are not round, not circular, and are elongated. Redtail scad has a unique form are called fusiform shape (Furlani, *et al.* 2008 and Tuset *et al.* 2003).

3.3. Relationship of total length and otolith size

Regression between TL and OL, TL and OW, TL and OP and TL and OA of *D. kurroides* from Kema Bay follows a power (multiplicative) function (Figure 4) or linear function after transformation to natural logarithm (Table 4). Figure 4. The power model of TL-OL, TL-OW, TL-OP and TL-OA relationship of *Decapterus kurroides* from Kema Bay.

Regression of the TL–Size (OL, OW, OP and OA) (Table 4) of *D. kurroides* of Kema Bay indicated variations in slopes (b) and corelations (r) in which *D. kurroides* from Kema Bay had higher (r>96 %). Similarly, b values characterizing the growth pattern show allometric growth in TL-OL, the TL-OW, the TL-OP and the TL-OA relationship.

Regression of the TL–Otolith Size (OL, OW, OP and OA) of juveniles, female and males *D. kurroides* of Kema Bay indicated variations in slopes (b) and corelations (r). Males *D. kurroides* from Kema Bay had highest correlation (r > 82 %). The b values characterizing the growth pattern show dominant allometric growth of TL-OL, the TL-OW, the TL-OP and the TL-OA relationship of juveniles, females and males. To compare the linear regression lines of ln(TL)–ln (Otolith size) as presented in Figure 5.

To compare the linear regression lines of ln (TL)–ln (Otolith size), ANOVA was employed (Table 5). For the regression of ln(TL) – ln(OL), because the p-value for the intercept and the slopes is greater or equal than 0.05 (a : F-ratio = 1.030; P = 0.311 and b : F-ratio = 2.230; p = 0.137), there are not statistically significant differences between for the intercept and the slopes for the various values of female and male at the 95% confidence level. Similarily with the regression of ln(TL) – ln(OP), there are not statistically significant differences between for the intercept and the slopes for the various values of female and male at the 95% confidence level

The comparison of linear regression of ln(TL)–ln(OW) and ln(TL)–ln(OP) there are statistically not significant differences between the intercepts for the various values of females and males. Because the p-value for the slope of ln(TL)–ln(OW) and ln(TL)–ln(OP) are less than 0.05 (F-ratio = 7.79; P = 0.006 and F-ratio = 6.250; P = 0.014), there are statistically significant differences between the intercepts for the various values of females and males at the 95% confidence level.

4. Conclusion

The otolith size and the shape index of *D. kurroides* from Kema Bay were successfully characterized. Significant difference was found in otolith size and shape index except otolith perimeter, rectangularity, ellipticity, and aspect ratio otolith between of *D. kurroides*. Therefore, the otolith size and shape of left-right sides of redtail scad from Kema Bay were asymmetrical. No significant differences were found in otolith size and shape index between left and right otoliths of juveniles or symmetrical, but significant differences between left and right otoliths of male and female *D. kurroides* from Kema Bay. The regressions between total length and otolith sizes (otolith length, width, perimeter and area) of *D. kurroides* follows a power function. The growth patterns showed dominant allometric growth in total length-otolith length, total length-otolith width total length-otolith perimeter, total length-otolith area relationships of *D. kurroides* from Kema Bay.

References

Arai T., Limbong, D., and Tsukamoto, K. 2000. Validation of otolith daily increments in the tropical eel *Anguilla celebesensis*. Canadian Journal of Zoology 78(6):1078-1084.

Arai T., Miller, M. J., and Tsukamoto, K. 2003. Larval duration of the tropical *eel Anguilla celebesensis* from Indonesian and Philippine coasts. Marine Ecology Progress Series 251:255-261.

Bahri, S., Lumingas, L.J.L. dan Manginsela, F.M. 2018. Analisis Biometri Otolit Ikan Selar Bentong, *Selar crumenophthalmus* (Bloch,1793) di Teluk Manado, Sulawesi Utara. J. Platax 6 (2) 124-138

Begg, G.A. and Brown, R.W. 2000. Stock identification of haddock (*Melanogrammus aeglefinus*) on Georges Bank based on otolith shape analysis. Trans. Am. Fish. Soc., 129: 935-945.

Campana S. E. and Casseleman, J. M. 2011. Stock Discrimination Using Otolith Shape Analysis. Canadian Journal of Fisheries and Aquatic Sciences 1993. 50(5) : 1062 – 1083. http://doi.org//10.1139/f93-123.

Draper N. R., and Smith H. 1998 Applied regression analysis. 3ʳᵈ edition, Wiley, New York, 736 pp.

Farley J. H., Eveson, J. P., Davis, T. L. O., Andamari, R., Proctor, C. H., Nugraha, B., and Davies, C. R., 2014. Demographic structure, sex ratio and growth rates of southern Bluefin tuna (*Thunnus maccoyii*) on the spawning ground. PloS ONE 9(5):e96392.

Furlani, D., Gales, R. and Pemberton, D. 2007. Otoliths of Common Australian Temperate Fish. A Photographic.Guide.CSIRO Publishing. Melbourne.

Helling K., Scherer, H., Hausmann, S., and Clarke, A. H. 2005. Otolith mass asymmetries in the utricle and saccule of flatfish. Journal of Vestibular Research 15(2):59-64

Kimura, S.; K. Katahira and K. Kuriiwa 2013. The red-fin Decapterus group (*Perciformes: Carangidae*) with the description of a new species Decapterus smithvanizi. Ichtyological Research (60) 363-379

Mamuaya, G.E., Manginsela, F.B. dan Mandey, C.F.T. 2017a. Otolit sagita ikan Selar crumenophthalmus (Bloch 1793) dari perairan pantai Kema, Sulawesi Utara. Simposium Nasional Ikan dan Perikanan Pantai. Bogor. 6 p.

Mamuaya, G.E., Manginsela, F.B., dan Mandey, C.F.T. 2017b. Struktur Mikro Batu Telinga Ikan Cakalang Katsuwonus pelamis. Semirata Mipanet Unsrat. Manado. 13 p.

Mamuaya, G.E., Manginsela, F.B., dan Lumenta, C. 2018. Stok ikan selar bentong dari perairan pantai semenanjung Minahasa berbasis otolit sagita. Seminar Nasional Kelautan XIII. Surabaya.

Manginsela F.B., Rondo, M., Rondonuwu, A.R., Kambey, A.D., dan Lumuindong, F. 2017. Ekologi Perairan Teluk Manado. Fakultas Perikanan dan Ilmu Kelautan, Universitas Sam Ratulangi. Manado.

Masuda, H., Araga, C., and Yoshino, T. 1975. Coastal Fishes Of Soththern Japan. Archipelago. Vol. 1. Tokai University Press, Tokyo, Japan.

Masuda, H., Amaoka, K., Araga, C., Uyeno, T., and Yoshino, T. 1984. Morfometrik the fishes Tokai University Press, Tokyo, Japan.

Maulita, M., Syarif, B., dan Sari, R.K. 2013. Aspek biologi dan perikanan ikan layang anggur (*Decapterus kurroides*) yang didaratkan di Pelabuhan Perikanan Nusantara (PPN) Pelabuhan Ratu, Sukabumi, Jawa Barat. STP Press.

Mogea D., R., dan Lumingas, L.J.L., dan Mamuaya, G.E. 2018. Analisis Biometeri Otolit (Sagita) untuk pemisahan stok ikan cakalang, Katsuwonus pelamis (*Linnaeus. 1758*) yang didaratkan di Pelabuhan Perikanan Pantai Tumumpa (Manado) Sulawesi Utara. J. Platax 7 (2) 401-412

Rumero, P. 2002. An etymological dictionary of taxonomy. Madrid, unpublish

Sumaila, U.R., Marsden, A.D., Watson, R., and Pauly, D. 2007. A global ex-vessel fish price database: construction and applications. J. Bioeconomics 9:39-51.

Sugeha H. Y., Shinoda, A., Marui, M., Arai, T., and Tsukamoto, K. 2001. Validation of otolith daily increments in the tropical eel *Anguilla marmorata*. Marine Ecology Progress Series 220:291-294.

Tuset, V.M., Lozano, I.J., González, J.A., Pertusa, J.F., and García-Díaz, M.M. 2003. Shape indices to identify regional differences in otolith morphology of scomber, Serranus cabrila (*L.,* 1758). J. Appl. Ichthyol., 19: 88-93

Taliawo R., Manginsela, F.B., dan Bataragoa, N.E. 2018. Morfometrik Otolit Ikan Selar (*Selar crumenophthalmus*) Dari Teluk Kema. J. Platax 6 (1) 98-106

Umar, Y., Manginsela, F.B. dan Monengkey, R.D. 2019. Otolit dan Pola Pertumbuhan Ikan Layang, Decapterus muroadsi Temminck & Schlegel. 1844 di Teluk Manado J. Platax 7, (1) 27-33

William A. J., Leroy, B. M., Nicol, S. J., Farley, J. H., Clear, N. P., Krusic-Golub, K., and Davies, C.R. 2013 Comparison of daily- and annual- increment counts in otoliths of bigeye (*Thunnus obesus*), yellowfin (*T. albacares*), southern bluefin (*T. maccoyii) and albacore* (*T. alalunga*) tuna. ICES Journal of Marine Science 70(7):1439-1450.

WORMS. 2019. FishBase. World Wide Web electronic by Froese, R. & D. Pauly (Editors). http://www.fishbase.org [Visit, Maret 2019]

Wujdi, A, Prihatiningsih dan Suwarso. 2016. Karakteristik morfologi dan hubungan morfometrik otolith dengan ukuran ikan lemuru (*Sardinela lemuru* Blekeer 1853) di Selat Bali. Bawal 8 (3) : 159 – 162

Wujdi A.; B., Setyadji dan Nugroho, S. C. 2017. Identifikasi struktur stok ikan cakalang (*Katsuwonus pelamis Linnaeus*, 1758) di Samudra Hindia (WPP NRI 573) menggunakan analisis bentuk otolit. Jurnal Penelitian Perikanan Indonesia, 23 (2): 77-88.

Wujdi A.; Agustina, M., dan Jatmiko, I. 2018. Indeks bentuk otolit ikan cakalang, Katsuwonus pelamis (*Linnaeus*, 1758) dari Samudra Hindia. Jurnal Iktiologi Indonesia 18(2):151-163.

Zengin, M., Saygin, S. and Polay, N. 2015. Otolith Shape Analyses and Dimensions of the Anchovy *Engraulis encrasicolus L.* in the Black and Marmara Seas. Sains Malaysiana 44(5): 657–662.