A SUMMARY OF SEA TURTLE GENETIC STUDIES IN THE INDIAN OCEAN AND SOUTHEAST

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Our summary has compiled available information about genetics of nesting and in-water sea turtle populations in the Indian Ocean and Southeast Asia so that others interested in this field of research might easily identify areas requiring further investigation. We have also identified studies with contradictory results that would benefit from additional investigation. Study outcomes have been presented without distinguishing among samples from different tissues or fluids, which included blood, skin, muscle, liver, eggshell, and egg albumen, as it was not anticipated that this would be an influential factor on the results.

GENETIC STRUCTURE OF NESTING SEA TURTLE POPULATIONS IN THE INDIAN OCEAN AND SOUTHEAST ASIA

Understanding the genetic structure of nesting populations is important to identify populations of conservation importance, determine population connectivity, and define management units within species (reviewed by Jensen *et al*., 2013a). Haplotypes known for nesting populations of green (Table 1 and 2), olive ridley (Table 3), hawksbill (Table 4 and 5), loggerhead (Table 6), leatherback (Table 7), and flatback (Table 8) sea turtles are presented below. Earlier studies utilised short (~380bp) mtDNA sequences but new mtDNA D-loop primers yield long (~800bp) sequences which improve resolution of stock structure and identify additional management units; it is recommended all future mtDNA studies utilise the longer sequences (see Abreu-Grobois *et al*., 2006; Shamblin *et al*., 2012). Studies such as Dutton *et al.* (2013) and Jensen *et al.* (2013b) have re-analysed shorter sequences and published additional haplotypes. New sequences should be designated a number according to guidelines at SWFC (2014) and ACCSTR (2014) and submitted to GenBank (www.ncbi.nim.nih.gov). The forthcoming manuscripts about green sea turtle haplotypes by Jensen *et al.* (see table 1) and hawksbill sea turtle haplotypes by FitzSimmons *et al.* (see Table 4) should resolve problems in understanding haplotypes for these species and understanding the relationship between previous sequence designations. It is hoped that future work can utilise longer sequences and potentially re-analyse samples collected previously, especially those still to be allocated a sequence number.

There is a lack of samples both by region (northwest Indian Ocean, eastern Africa, Bangladesh, Sri Lanka) and species (leatherback, loggerhead, olive ridley and flatback sea turtles) which could be addressed by collaboration between researchers in the appropriate region and those at labs with the capacity to conduct molecular genetics. As FitzSimmons (2014) explains in the preceding paper of this issue of IOTN, greater resolution of population stock structure in the Indian Ocean will inform more effective management plans and conservation efforts of the genetically diverse sea turtle populations in the Indian Ocean and Southeast Asia.

Table 1. Known Haplotypes of Nesting Green Sea Turtles (*Chelonia mydas*) in the Indian Ocean. Jensen *et al.* (In Prep) will standardise all of the haplotype names and show the relationship among past names. No published haplotypes for the east coast of Africa, or central Indian Ocean (including Sri Lanka, Maldives and Chagos) could be found.

		Original Haplotype (Current Sequence Designation)																																			
Country, Location and Reference	**n**	**Aa**	**A1 (CmP76)**	**A2 (CmP47)**	**A3 (CMP20)**	**B4 (CmP81)**	**C1 (CmP83)**	**C2 (CmP86)**	**C3 (CmP49)**	**C4 (CmP87)**	**C8 (CmP89)**	**C9 (CmP90)**	**C14 (CmP91)**	**Caru(CmP91)**	**CM8**	**CMKWI**	**CMKW2**	**CMKW3**	**CMKW4**	**CMKW5**	**CMOM1 (CmP73)**	**CMOM2 (CmP72)**	**CMOM3 (CmP62)**	**CMOM4 (CmP71)**	**D2 (CmP57)**	**Glo33**	**H1 (CmP62)**	**H2 (CmP63)**	**H3 (CmP64)**	**IND1 (CmP49)**	**IND2 (CmP57)**	**IND3 (CmP75)**	**L1 (CmP71)**	**L2 (CmP72)**	**L3**	**May23**	**NRC**	**z**	**TBA**
Arabian Peninsular[1]	44																										X	X	X				X	X	X				X
Australia, Ashmore Reef[2,3]	20			X	X		X		X																														
Australia, Bountiful Is[2]	20						X		X	X	X																												
Australia, Bountiful Is[3]	49						X		X		X																												
Australia, Groote Eylandt[2]	23						X		X		X			X																									
Australia, Groote Eylandt[3]	23						X		X		X		X																										
Australia, Lacepedes Islands[2,3]	30			X		X	X		X			X																											
Australia, Northwest Cape[2]	15						X	X	X			X		X																									
Australia, Northwest Cape[3]	15						X	X	X			X	X																										
Australia, Port Bradshaw[2]	43						X		X	X	X																												
Australia, Port Bradshaw[3]	60				X		X		X		X																												
Australia, Scott Reef[2,3]	19			X			X		X			X																											
Chagos Islands, Chagos Bank[1]	2	X							X																														
Chagos Islands, Danger & Nelson Islands[4]	2	X							X																														
Chagos Islands, Salomon Atoll[1,4]	1								X																														
Comoros, Moheli[5]	10																													X	X	X					X		
Comoros, Moheli[6]	34		X	X					X						X										X											X			
French Esparses Islands, Tromelin Island[6]	44			X					X																														
Kuwait, Qaruh Is & Umm Al-Maradim Is[7]	95														X	X	X	X	X		X																		

Country, Location and Reference	n	Aa	A1 (CmP76)	A2 (CmP47)	A3 (CMP20)	B4 (CmP81)	C1 (CmP83)	C2 (CmP86)	C3 (CmP49)	C4 (CmP87)	C8 (CmP89)	C9 (CmP90)	C14 (CmP91)	Caru(CmP91)	CM8	CMKWI	CMKW2	CMKW3	CMKW4	CMKW5	CMOM1 (CmP73)	CMOM2 (CmP72)	CMOM3 (CmP62)	CMOM4 (CmP71)	D2 (CmP57)	Glo33	H1 (CmP62)	H2 (CmP63)	H3 (CmP64)	IND1 (CmP49)	IND2 (CmP57)	IND3 (CmP75)	L1 (CmP71)	L2 (CmP72)	L3	May23	NRC	z	TBA
Madagascar, Nosy Iranja[6]	13								X																														
Mozambique Channel, Europa Island[6]	33								X						X																								
Mozambique Channel, Juan de Nova Island[6]	20								X						X																								
Mozambique Channel, Mayotte[6]	41		X	X					X						X																				X				
Mozambique Channel, Gloriseuses[6]	39		X						X																	X													
Oman[8]	?																				X	X	X	X															
Reunion[1]	55	X							X																													X	X
Seychelles, Aldabra[1]	26	X							X																														X
Seychelles, Aldabra[6]	26		X	X					X																														
Seychelles, Cosmoledo[1]	33	X	X						X																														X
Seychelles, Cosmoledo[6]	31		X	X					X																														
Seychelles, Farquhar[1]	9	X							X																														X
Seychelles, Farquhar[6]	7		X	X					X																														
Seychelles, Granitics[1]	2								X																														X

*See green turtle mtDNA sequences maintained by SWFSC (2014). [1]Broderick *et al.* (1998). Unknown length segment from mtDNA control region. Primers TCR5, TCR6GC; [2]Moritz *et al.* (2002). 384bp sequence of mtDNA control region. Primers not named; [3]Dethmers *et al.* (2006). 384bp sequence from mtDNA control region. Primers TCR5, TCR6GC; [4]Mortimer & Broderick (1999). Segment of mtDNA control region. Primers TCRS, TCR6GC; [5]Formia *et al.* (2006). 488bp sequence from mtDNA control region. Primers LTCM1, HDCM1, LTCM1-HDCM1.1, LTCM1.1-HDCM1; [6]Bourjea *et al.* (2007). 396bp sequence from mtDNA control region. Primers TCR-5, TCR-6; [7]Al-Mohanna *et al.* (2013). ~400bp sequence from mtDNA control region. Primers HDCM-1, TCR-5. [8]Alansari (Unpubl). Unknown length segment from mitochondrial D-loop. Primers not described.

Table 2 .Known Haplotypes of Nesting Green Sea Turtles (*Chelonia mydas*) in Southeast Asia. Jensen *et al.* (In Prep) will standardize all of the haplotype names and show the relationship among past names.

		Original Haplotype (Current Sequence Designation)																																				
Country, Location and Reference	**n**	**A1 (CmP76)**	**A2 (CmP47)**	**A3 (CMP20)**	**A6 (CmP67)**	**B1 (CmP44)**	**B3 (CmP80)**	**B4 (CmP81)**	**B5 (CmP82)**	**B6**	**C3 (CmP49)**	**C4 (CmP87)**	**C5 (CmP40)**	**C7 (CmP88)**	**C14 (CmP91)**	**Caru (CmP91)**	**CmP18**	**D2 (CmP57)**	**G2**	**G3**	**G4**	**G5**	**G7**	**G11**	**G12**	**G13**	**G14**	**G15**	**J14212**	**M1**	**M2**	**M3**	**P1**	**P2**	**R1**	**T1**	**T2**	**T3**
Brunei, Brunei Beach[1]	4										X	X						X																				
Indonesia, Derawan Island[1]	22			X							X		X					X												X			X	X				
Indonesia, Enu[1,3]	28			X											X																							
Indonesia, Enu[2]	28			X												X																						
Indonesia, Pangumbahan1	23										X	X																										
Indonesia, Pangumbahan[2,3]	23										X		X																									
Indonesia, Panjang Is[1]	16			X							X		X	X				X												X								
Indonesia, Sangalaki Is[1]	38				X						X		X		X			X												X								
Indonesia, Sangalaki[2]	29										X		X			X		X											X									
Indonesia, Sangalaki Is[3]	29				X						X		X		X			X																				
Malaysia, Mal. Turtle Islands[3]	28										X							X																				
Malaysia, Pahang[1]	12										X								X	X	X																	
Malaysia, Paka[1,3]	15								X		X																											
Malaysia, Palau Redang[2]	27								X		X	X				X																						
Malaysia, Perak[1]	15										X											X																
Malaysia, Redang Is[1]	31								X			X			X			X							X	X	X								X			
Malaysia, Redang Is[3]	12								X		X	X			X																							
Malaysia, Sabah Turtle Islands[1]	58										X			X				X																				
Malaysia, Sarawak[1]	62								X		X	X												X						X								
Malaysia, Sarawak Turtle Islands[2,3]	22								X		X	X																										

Country, Location and Reference	n	A1 (CmP76)	A2 (CmP47)	A3 (CMP20)	A6 (CmP67)	B1 (CmP44)	B3 (CmP80)	B4 (CmP81)	B5 (CmP82)	B6	C3 (CmP49)	C4 (CmP87)	C5 (CmP40)	C7 (CmP88)	C14 (CmP91)	Caru (CmP91)	CmP18	D2 (CmP57)	G2	G3	G4	G5	G7	G11	G12	G13	G14	G15	J14212	M1	M2	M3	P1	P2	R1	T1	T2	T3
Malaysia, Sipadan Is[1]	40										X		X		X			X					X															
Malaysia, Sipidan[2]	30										X		X			X		X																				
Malaysia, Sipidan Is[3]	30										X		X		X			X																				
Malaysia & Philippines, Turtle Islands[2]	67										X		X					X																				
Myanmar, Coco Is[1]	30		X								X	X	X		X															X	X	X						
Myanmar, Tameahla Is[1]	30										X	X			X															X								
Phillippines, APO Reef NP[1]	4										X																											
Philippines, Panikian Is[1]	9			X																																		
Phillippines, Phil. Turtle Islands[1,3]	62										X		X					X																				
Thailand, Huyong Is[1]	19								X		X																									X		
Thailand, Huyong Is[4]	19	X				X	X																															
Thailand, Khram Is[1]	30				X				X		X			X			X																				X	X
Thailand, Khram Is[4]	30	X	X	X		X		X	X	X																												
Vietnam, Con Dao Is[1]	42										X		X															X			X							
Vietnam, Minh Chau[1]	11										X																											

*See green turtle mtDNA sequences maintained by SWFSC (2014). [1]Arshaad & Kadir (2008). 389bp sequence of mtDNA control region. Primers TCR5, TCR1; [2]Moritz *et al.* (2002). 384bp sequence of mtDNA control region. Primers not described; [3]Dethmers *et al.* (2006). 384bp sequence from mtDNA control region. Primers TCR5, TCR1GC; [4]Kittiwattanawong *et al.* (2003). 438bp sequence from mtDNA control region. Primers Green15552F, Green15579F, Green16300R, Green16087R. See also Joseph (2013, 2014) for descriptions of additional studies in Malaysia.

Table 3. Known Haplotypes of Nesting Olive Ridley Sea Turtles (*Lepidochelys olivacea*) in the Indian Ocean and Southeast Asia. Some longer haplotypes (Lo#) overlap with shorter sequences (H, J). Samples are required for nesting populations in the northwest Indian Ocean (Oman), northeast Indian ocean (Bangladesh, Myanmar and Thailand), in the South China, Arafura and Timor Sea.

		Published Haplotype (Shorter Sequence)																				
Country, Location and Reference	**n**	**G**	**H**	**I**	**J**	**K**	**K1**	**K2**	**K3**	**K4**	**K5**	**N**	**New3**	**New6**	**Lo1 (J)**	**Lo2 (G)**	**Lo3**	**Lo4 (H)**	**Lo5**	**Lo15 (J)**	**Lo21**	**Lo27**
Australia, Flinders Beach[1]	9														X	X	X			X		X
Australia, McClure Islands[1]	11														X	X				X		
Australia, McClure Islands[2]	8	X			X																	
Australia, Tiwi Islands[1]	64														X	X	X	X	X		X	
India, Andaman & Nicobar Islands[2]	?				X	X	X		X	X	X											
India, Goa, Kerala, Lakshadweep, Orissa & Tamil Nadu[2]	?		X		X	X	X	X	X	X	X		X	X								
India, Orissa[3]	81				X	X	X	X	X	X	X	X										
Malaysia, Kijal and Paka[4]	5				X																	
Sri Lanka, SW coast[4]	17		X	X	X	X																

[1]Jensen *et al.* (2013b). ~880bp fragment of mtDNA control region. Primers LTEi9, H950. [2]Shanker *et al.* (2011). 350bp sequence from mitochondrial d-loop region. Primers HDCM1, LDCM1, LTCM1, TCR1-TCR6; [3]Shanker *et al.* (2004). 400bp sequence from mtDNA control region. Primers HDCM1, TCR5; [4]Bowen *et al.* (1998). 470bp sequence from mtDNA control region. Primers LTCM1, HDCM1.

Table 4. Known Haplotypes of Nesting Hawksbill Sea Turtles (*Eretmochelys imbricata*) in Southeast Asia. FitzSimmons et al. (In Prep) will describe new haplotypes, standardise all of the haplotype names, and show the relationship among past names.

		Haplotype														
Country, Location and Reference	**n**	**Ei1**	**Ei2**	**Ei3**	**Ei4**	**Ei5**	**Ei6**	**Ei7**	**Ei8**	**Ei9**	**Ei10**	**Ei11**	**Ei12**	**Ei13**	**Ei14**	**Ei15**	**14**
Bruni, Brunei Beach[1]	4				X					X	X						
Indonesia, Kimar Belitang[1]	9									X	X						
Indonesia, Seribu Islands[2]	9																X
Malaysia, Melaka[1]	29									X							
Malaysia, Sabah Turtle Islands[1]	20		X							X	X				X	X	
Myanmar, Coco Island[1]	4	X								X						X	
Philippines, APO Reef NP[1]	4					X	X	X									
Philippines, Bataan[1]	1										X						
Philippines, Davao Gulf[1*]	2								X					X			
Philippines, Misamis Oriental[1]	1			X													
Thailand, Khram Island[1]	14									X		X	X				

[1]Arshaad & Kadir (2008). 740bp sequence of mtDNA control region. Primers LTE19, H950; [2]Okayama *et al.* (1999). Fragment of unknown length from control region of DNA. Primers L15921, TCR1; *Written as Dava0 Gulf in Arshaad & Kadir (2008). See also Vargas et al. (2013) for haplotypes EIIP-33 and EiATL from Indo-Pacific turtles.

Table 5. Known Haplotypes of Nesting Hawksbill Sea Turtles (*Eretmochelys imbricata*) in the Indian Ocean. FitzSimmons *et al.* (In Prep) will standardise all of the haplotype names and show the relationship among past names. Further samples is required in the southwest Indian Ocean and northwest Indian Ocean (including Yemen and Oman), and northeast Indian Ocean (Andaman and Nicobar Islands).

		Haplotype																									
Country, Location and Reference	**n**	**AAAAAAA**	**BAAAAAA**	**CAAAAAA**	**ABAAAAA**	**A1**	**A6**	**A7**	**B3**	**B9**	**E1**	**E2**	**E3**	**E5**	**Iran1**	**Iran2**	**Iran3**	**Iran4**	**Iran5**	**Iran6**	**Iran7**	**PG7.1**	**PG7.2**	**PG7.3**	**PG7.4**	**PG7.5**	**TBA**
Arabian Peninsular[1,2]	14					X																					
Australia, Western Australia[2]	31						X	X																			
Chagos Islands, Diego Garcia[1,2]	3										X																
Chagos Islands, Peros Banhos[1,2]	5										X	X	X														
Chagos Islands, Salomon Atoll[1,2]	1										X																
Iran, Kish and Qeshm Islands[3]	30														X	X		X	X	X							
Iran, Kish and Qeshm Islands[4*]	45														X	X	X	X	X	X	X						
Iran, Hendoourabi, Nakhiloo, Ommolkaram & Sheedver[5]	-																					X	X	X	X	X	
Iran, Kish, Nakhiloo & Qeshm Islands[6,7]	69	X	X	X	X																						
Seychelles, Aldabra[1]	2										X																
Seychelles, Amirantes[1]	24									X	X	X															X
Seychelles, Cosmoledo[1]	2										X																
Seychelles, Farquhar[1]	1									X																	
Seychelles, Granitics[1]	32					X				X	X	X															X
Seychelles, Platte Island[1]	25									X	X	X															X
Seychelles, Undescribed location[2]	73					X			X		X	X		X													

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[1] Broderick *et al.* (1998). Segment of mtDNA control region. Primers TCR5, TCR1GC; [2] Mortimer & Broderick (1999). Segment of mtDNA control region. Primers TCR5, TCR1GC; [3] Tabib *et al.* (2011). 890bp sequence from mtDNA control region. Primers H950, LCM15382; [4] Tabib *et al.* (2014). 890bp sequence from mtDNA control region. Primers H950, LCM15382; [5] Mobaraki *et al.* (2014). Sample size unknown; six additional haplotypes not named in conference abstract; [6] Nezhad *et al.* (2012) and [7] Nezhad *et al.* (2013) Unknown length sequence from mtDNA control region. Primers H950, LCM15382. *Referred to as loggerhead turtles in Methods but hawksbills otherwise throughout the paper. See also Vargas *et al.* (2013) for haplotypes EIIP-33 and EiATL from Indo-Pacific turtles.

Table 6. Known Haplotypes of Nesting Loggerhead Sea Turtles (*Caretta caretta*) in the Indian Ocean. Haplotypes for the the major regional rookery in Yemen are currently unkown.

		Haplotype			
Country, Location and Reference	**n**	**D**	**F**	**CC-A11.6**	**CC-A2.1**
Oman, Masirah Island[1,2]	8		X	X	
South Africa, Tongaland[1,2]	15	X			X

[1]Bowen *et al.* (1994). Unknown fragment length from closed-circular mtDNA; [2]Shamblin *et al.* (2014). ~800bp from mtDNA control region. Primers LCM15382, H950g. See also Pacioni *et al.* (2013) for descriptions of studies in Western Australia.

Table 7. Known Haplotypes of Nesting Leatherback Sea Turtles (*Dermochelys coriacea*) in the Indian Ocean and Southeast Asia. Greater sampling in the northeast Indian Ocean would improve understanding of the number and range of management units.

		Published Haplotype (Shorter Sequence)						
Country, Location and Reference	**n**	**A**	**D**	**E**	**H**	**I**	**Dc1.1***	**Dc1.4***
India, Great Nicobar Is[1]	114	X	X	X		X		
Indonesia, Papua, Jamursba-Medi[2]	31	X	X	X		X		
Indonesia, Papua, War Mon[2]	9					X		
Malaysia, Terengganu[3]	9	X	X	X	X			
Papua New Guinea[2]	18	X	X	X		X		
South Africa, Tongaland[3]	8	X						
South Africa, Natal[4]	41						X	X

[1]Shanker *et al.* (2011). 350bp fragment of control region of mtDNA. Primers HDCM1, LDCM1, LTCM1, TCR1-TCR6; [2]Dutton *et al.* (2007). 496bp fragment of control region of mtDNA. Primers LTCM2, HDCM2; [3]Dutton *et al.* (1999). 496bp fragment of control region of mtDNA. Primers LCM15382, HDCM1; [4]Dutton *et al.* (2013). 832bp sequence from D-loop of mtDNA. Primers LCM15382, H950g; *Haplotype A in Dutton *et al.* (1999).

Table 8. Known Haplotypes of Nesting Flatback Sea Turtles (*Natator depressus*) in the Indian Ocean.

		Haplotype										
Country, Location and Reference	**n**	**Nd1**	**Nd2**	**Nd3**	**Nd4**	**Nd6**	**Nd7**	**Nd8**	**Nd9**	**Nd10**	**Nd11**	**Nd12**
Australia, Bare Sand Is	16	X					X			X		
Australia, Barrow Is	29	X	X	X	X							
Australia, Cape Domett	35	X	X	X								
Australia, Cape Thouin	25	X	X	X	X							
Australia, Eco Beach	28	X	X	X							X	
Australia, Field Is	38	X	X				X	X	X	X		
Australia, West Island	31	X				X	X			X	X	X

All haplotypes from FitzSimmons *et al.* (unpubl.) in Pittard (2010).

GENETIC STRUCTURE OF FEEDING GROUND SEA TURTLE POPULATIONS IN THE INDIAN OCEAN AND SOUTHEAST ASIA

Haplotypes known for feeding ground populations of loggerhead (Table 9), green (Table 10 and 11) and hawksbill (Table 12 and 13) sea turtles are presented below. There are no known haplotypes of foraging olive ridley, leatherback or flatback sea turtles in the Indian Ocean. As for nesting populations, new mtDNA D-loop primers yield long (~800bp) sequences should be utilised in future studies and new sequences should be submitted to GenBank (www.ncbi.nim.nih.gov) and numbered according to sequences at SWFC (2014) and ACCSTR (2014).

Table 9. Known Haplotypes of Foraging Loggerhead Sea Turtles (*Caretta caretta*) in the Indian Ocean

		Haplotype
Country, Location and Reference	**n**	**C (CcA11)**
Kuwait, southern Kuwait Bay	1	X

Al-Mohanna & George (2010). 306bp sequence from D-loop of mtDNA. Primers HDCM-1, TCR-5. See also Pacioni *et al.* (2013) for descriptions of studies in Western Australia.

Table 10. Known Haplotypes of Foraging Green Sea Turtles (*Chelonia mydas*) in Southeast Asia. Jensen *et al.* (In Prep) will standardise all of the haplotype names and show the relationship among past names.

		Haplotype										
Country, Location and Reference	**n**	**A2**	**A3**	**Caru**	**C3**	**C4**	**C5**	**C8**	**C14**	**D2**	**E2**	**L1**
Brunei, Lawas[1]	28		X		X	X	X		X	X		X
Malaysia, Tun Sakaran MP & Sabah, Sipadan Is[2]	65	X	X	X	X		X			X	X	
Sabah, Sipadan Is[3,4]	33	X	X	X	X		X			X	X	
Sabah, Mantanani and Mengalum Islands[5,6]	20			X	X	X		X		X	X	

[1]Arshaad *et al.* (2013). Undescribed length sequence from mtDNA control region. Primers H950, LTEi9; [2]Kuen & Joseph (2013). Segment of mtDNA not described. Primers TC5, TC6; [3]Joseph & Kuen (2012), [4]Joseph & Kuen (2014). 380bp segment of mtDNA control region. Primers not described; [5]Kuen & Joseph (2011) and [6]Kuen & Joseph (2014). Segment of mtDNA control region. Primers TCR5, TCR6.

Table 11. Known Haplotypes of Foraging Green Sea Turtles (*Chelonia mydas*) in the Indian Ocean. Jensen *et al*. (In Prep) will standardise all of the haplotype names and show the relationship among past names.

Country, Location and Reference	n	Haplotype																																		
		Aa	Ac	A1	A2	A3	A7	B1	B3	B6	B7	C1	C3	C4	C5	C7	C8	C9	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	D2	D5	K1	x	z	TBA
Australia, Aru Is[1]	40					X	X	X				X	X		X				X												X					
Australia, Ashmore Reef[1]	65				X	X		X				X	X	X	X	X		X	X											X			X			
Australia, Cobourg Peninsula[1]	91			X	X	X		X		X		X	X	X	X			X			X	X	X								X	X				
Australia, Field Island[1]	62				X	X	X	X				X	X	X		X	X	X	X					X	X	X	X			X	X					
Australia, Fog Bay[1]	67					X					X	X	X	X	X		X	X	X							X		X	X							
Australia, Sir Edward Pellew Islands[1]	102				X			X	X			X	X	X			X																			
Chagos Islands, Diego Garcia[2]	1											X																								
Cocos KeelingIslands[1,2]	36											X	X							X																
Seychelles, Aldabra[2]	75	X	X	X									X																						X	X
Seychelles, Amirantes[2]	48	X										X	X																					X		X
Seychelles, Farquhar[2]	8	X		X									X																							
Seychelles, Providence[2]	25	X		X								X	X																						X	X

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[1]Dethmers *et al*. (2010). 385bp segment of mtDNA control region. Primers TCR5, TCR6; [2]Broderick *et al*. (1998). Segment of mtDNA control region. Primers TCR5, TCR1GC.

Table 12. Known Haplotypes of Foraging Hawksbill Sea Turtles (*Eretmochelys imbricata*) in the Indian Ocean.

		Haplotype																
Country, Location and Reference	**n**	**A1**	**B3**	**B9**	**B10**	**E1**	**E2**	**E3**	**E4**	**u**	**w**	**x**	**y**	**z**	**3**	**23**	**24**	**TBA**
Chagos Islands, Chagos Bank[1]	1					X												
Chagos Islands, Diego Garcia[1]	40	X		X		X	X						X					
Chagos Islands, Peros Banhos[1]	4			X		X	X											
Chagos Islands, Salomon Atoll[1]	6	X		X		X	X					X						X
Chagos Islands[2]	50	X	X		X	X	X		X									
Maldives[3]	1														X			
Seychelles, Undescribed location[3]	7														X	X	X	
Seychelles, Aldabra[1]	104	X		X		X	X			X	X		X					X
Seychelles, Amirantes[1]	15	X		X		X	X			X			X	X				X
Seychelles, Granitics[1]	17																	X
Seychelles, Platte Island[1]	1					X	X											X
Seychelles, Providence[1]	21	X		X		X							X					X
Seychelles, Undescribed location[2]	191	X	X	X	X	X	X	X	X		X							

[1]Broderick *et al.* (1998). Segment of mtDNA control region. Primers TCR5, TCR1GC; [2]Mortimer & Broderick (1999). Segment of mtDNA control region. Primers TCR5, TCR1GC; [3]Okayama *et al.* (1999). Unknown length sequence from mitochondrial control region. Primers L15926, TCR6.

Table 13. Known Haplotypes of Foraging Hawksbill Sea Turtles (*Eretmochelys imbricata*) in Southeast Asia. Fitzsimmons *et al.* (In Prep) will describe new haplotypes, standardise all of the haplotype names, and show the relationship among past names.

		Haplotype		
Country, Location and Reference	**n**	**1**	**H1**	**H4**
Malaysia, Tun Sakaran MP and Sabah, Sipadan Is[1]	4		X	X
Philippines[2]	2	X		

[1]Kuen & Joesph (2013). Primers TC5 and TC6; [2]Okayama *et al.* (1999). Fragment of unknown length from control region of DNA. Primers L15921, TCR1.

GENETIC DIVERSITY AMONG SEA TURTLE NESTING BEACHES IN THE INDIAN OCEAN AND SOUTHEAST ASIA

Genetic diversity has been described among nesting olive ridley sea turtles in India (Shanker *et al.*, 2011) and Australia (Jensen *et al.*, 2013b); hawksbill turtle populations in the Persian Gulf (Mostafavi *et al.*, 2011; Zolgharnein *et al.*, 2011; Tabib *et al.*, 2011, 2014; Nezhad *et al.*, 2012, 2013); and, green turtle populations in Thailand (Kittiwattanawong *et al.*, 2003), Malaysia (Joseph, 2013, 2014), Sri Lanka (Ekanayake *et al.* (2012), and the Mozambique channel (Bourjea *et al.*, 2007). The population genetics of hawksbill turtles in the Persian Gulf have been summarized in Table 14 due to contradictory results that may be the result of different methodologies among studies. The importance of understanding genetic diversity among nesting populations has been reviewed by FitzSimmons and Limpus (2014).

OTHER MOLECULAR GENETICS STUDIES IN THE INDIAN OCEAN AND SOUTHEAST ASIA

The use of microsatellite markers to understand paternity and mating systems in sea turtles is reviewed by Jensen *et al.* (2013a), and studies on paternity of sea turtle nesting populations in the region are summarised in Table 15.

DNA barcoding can be used for species identification, such as during forensic investigation of the species of turtle eggs or meat for commercial sale. Elmeer *et al.* (2011) has sequenced the cytochrome c oxidase subunit I (COI or cox1) gene from mitochondrial DNA of green turtles in Qatar for use in DNA barcoding. In a different type of forensic DNA analysis, 57 items made from tortoiseshell that had been confiscated by the US Fish and Wildlife Service identified 16 haplotypes, 94% of which were of Indo-Pacific origin (Shattuck, 2011).

Table 14 .Genetic Diversity Among Sea Turtle Nesting Beaches in the Persian Gulf.

Country, Location and Reference	Species	n	Genetic Marker	Results
Iran, Hormoz & Shidvar Islands[1]	*Eretmochelys imbricata*	60	8 microsatellite loci	Hormoz Is: Av HO=0.39, Av. HE=0.77; Shidvar Is: Av HO=0.53, Av. HE=0.77; All loci in two regions have differentiations from Hardy-Weiberg equilibrium. Fst=0.048 P<0.01; DTN=0.27. Populations at the two islands are significantly different.
Iran, Kish & Qeshm Islands[2]	*Eretmochelys imbricata*	30	5 haplotypes	Kish Is: h=0.64, π=0.002; Qeshm Is: h=0.77, π=0.001; Overall: h=0.69, π=1.56. Results indicate low genetic diversity in this area and high rates of migration between the populations of these two islands.
Iran, Kish & Qeshm Islands[3]	*Eretmochelys imbricata*	45	7 haplotypes	Kish Is: h=0.111, π=0.0002; Qeshm Is: h=0.313, π=0.0006; Overall: h=0.212, π=0.00038. Fst=0.999±0.0002; Nm=0.000. Results suggest low genetic diversity in this area but a significant difference between the nesting populations of Kish and Qeshm Islands.
Iran, Kish & Qeshm Islands[4]	*Eretmochelys imbricata*	64	5 microsatellite loci	Average Ho=0.570, Av. HE=0.616. Eight out of 10 tests differed significantly from Hardy-Weinberg Equilibrium P<0.05. FST=0.167 P<0.01; RST= 0.634; Nm=1.26; Genetic distance=0.33; Genetic similarity=0.78. The turtle populations of Kish and Qeshm Islands are significantly different.
Iran, Kish, Qeshm & Nakhiloo Islands[5,6]	*Eretmochelys imbricata*	69	4 haplotypes	Significant genetic variation among turtles nesting at these islands was not detected P>0.05.

[1]Mostafavi *et al.* (2011); [2]Tabib *et al.* (2011); [3]Tabib *et al.* (2014); [4]Zolgharnein *et al.* (2011); [5]Nezhad *et al.* (2012); [6]Nezhad *et al.* (2013).

Table 15 . Studies on Paternity of Green and Hawksbill Turtle Nests in the Indian Ocean and Southeast Asia.

Country, Location and Reference	Species	Total # Females Examined	Total # Clutches Examined	# Single Clutches	# Successive Clutches	# Hatchlings Examined from Each Clutch	Results
Seychelles, Cousine Island[1]	*Eretmochelys imbricata*	43	51	42	•2 clutches from 7 females •3 clutches from 5 females •4 clutches from 1 females	3-20	•Single paternity (90.7% of females) more common than multiple paternity (9.3% of females). •Two fathers in 100.0% of clutches with multiple paternity. •No males appeared to have fertilized >1 female. •Evidence that females predominantly monogamous and store sperm within a nesting season
Sri Lanka, Kosgoda[2]	*Chelonia mydas*	19	24	17	•3 clutches from 1 female •4 clutches from 1 females	10	•Single paternity (53% of females) more common than multiple paternity (47% of females). •Two fathers in 12.5% of clutches with multiple paternity. •Three fathers in 37.5% of clutches with multiple paternity. •No males appeared to have fertilized >1 female. •Evidence of male/s siring first clutch also siring successive clutches, therefore, females mate with same male multiple times during a nesting season and/or sperm storage.

[1]Phillips *et al.* (2013). 33 variable microsatellite loci examined using two leatherback primers (D1 and D110) and four adapted hawksbill primers (Eim11, Eim38, Eim41, HKB31); [2]Ekanayake *et al.* (2013). 1 microsatellite loci using four green turtle primers (Cm3, Cm58, Cm72, Cm84) and two loggerhead turtle primers (Cc7, Cc117).

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A SUMMARY OF THE INDIAN OCEAN AND SOUTH EAST ASIA REGIONAL MEETING AT NEW ORLEANS , USA

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This year, the Indian Ocean and South East Asia Regional Meeting (IOSEA) was held on 13th April in New Orleans, USA, prior to the 34th International Sea Turtle Symposium. Approximately 20 participants from 15 countries, including Australia, Bangladesh, France, Japan, Malaysia, Mozambique, Philippines, Seychelles, Sri Lanka, Tanzania, United Arab Emirates, United Kingdom and United States, attended. Lalith Ekanayake (co-organiser of the meeting) gave a brief introduction to the meeting, its history, and welcomed new participants before introducing seven presentations.

Jeanne Mortimer described the status of sea turtle research and conservation in the Seychelles and Chagos Islands. She explained new initiatives for the outer island, progress of the satellite tagging programme and genetic studies, and the sand temperature monitoring programme. Peter Richardson discussed the IOSEA Western Indian Ocean Marine Turtle Task Force and 8th WIOMSA Scientific Symposium held in Mozambique in November 2013. Jeff Miller summarised the current research on sea turtles in Saudi Arabia. Teri Shore discussed threats from industrialisation of the Great Barrier Reef and potential harm to sea turtle nesting beaches and marine habitat in the area. Andrea Phillott (co-organiser of the meeting) described her current research on hatchery management practices in the Indian Ocean and Southeast Asia region. Hiroyuki Suganuma discussed broad aspects of sea turtle conservation and management issues in Japan, including protection of nests from monitor lizards.

During the general discussion, participants raised topics of general interest. Lalith Ekanayake described the recent theft of albino turtles from a turtle hatchery in Sri Lankan. Nick Pilcher raised a question about turtle by-catch and pointed out that there are very few studies on turtle by-catch in the region. He suggested regional participants consider focusing on small scale fishery by-catch of sea turtles and explained about the CMS dugong survey methodology and concurrent collection of turtle by-catch data within the same survey. Mark Guinea raised the potential impact of port development in Asian countries.

The next meeting will be held in Turkey before the 35th International Sea Turtle Symposium. We hope more regional participants will be able to attend as the venue is closer and travel will be cheaper.