



“The Lost Princess (*putri duyung*)” of the Small Islands: Dugongs around Sulawesi in the Anthropocene

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In the Spermonde as in the other main island groups around Sulawesi, seagrass and coral ecosystems are intimately linked ecologically and overlap extensively on the shallow water shelves surrounding most islands. One keystone species living in these shallow waters is the dugong (*Dugong dugon*). Officially fully protected under Indonesian Law (PP7/1999), published data on dugongs in the islands around Sulawesi are extremely limited. In this research, we collected, compiled and evaluated data and information (mostly unpublished) on the distribution, exploitation and community perceptions of dugongs around Sulawesi, including the Togean, Banggai, Spermonde, Taka Bone Rate/Selayar, and Tanakeke Islands. Opportunities for dugong conservation, and potential benefits for coral reef ecosystems in a small island socio-ecological context, were considered. Once common within living memory, socio-economic data indicate that Sulawesi dugongs are now rare and under severe threat. Many fishing communities consider dugong meat superior to beef, and see it as a welcome change from fish, while certain body parts fetch a high price, as do dugong tears. In the Spermonde Islands, dugongs may already have been extirpated; the most recent reported sighting was in 1993 when the capture of an adult dugong by fishermen of Barranglompo Island resulted in an impromptu festival. All these Sulawesi small islands communities have dugong princess (*putri duyung*) legends with potential as an entry-point to hearts and minds. Preventing further extirpations and striving to bring back the “lost princess” could be an iconic component of moving toward sustainability in small-island socio-ecological systems.

Keywords: endangered species exploitation, *Sirenia*, tropical small island ecosystems, local knowledge and perception, flagship species, folklore, marine mammal conservation, extirpation

INTRODUCTION

In a small island context, seagrass and coral reef ecosystems are generally intimately linked through flows of both energy and matter, as well as biological structure and processes (Unsworth et al., 2007, 2008, 2012; Bouillon and Connolly, 2009; Davis et al., 2009; Grober-Dunsmore et al., 2009; Stapel, 2012). In practice, the dividing line between these two ecosystems is often hard to define; while from a biological perspective the life cycles of many species include phases where both coral reef and seagrass habitats are important or even vital (Krumme, 2009). Herbivory in seagrass meadows

is an important process, resulting in significant export of nutrients to coral reefs (Vonk et al., 2008; Stapel, 2012) as well as promoting carbon storage in seagrass meadow substrates (Duarte, 2002). There is growing evidence that mega-herbivores play a key role on both of these processes, in particular green turtles and dugongs (Preen, 1992, 1995a; Carruthers et al., 2002; Heithaus et al., 2014; Lutz and Martin, 2014).

The dugong (*Dugong dugon*) is the only surviving member of the Family Dugongidae, in the Order Sirenia; as the only mammalian marine herbivores, the sirenians are also commonly referred to as sea cows (Anderson, 2002). The literature on sirenian phylogeny and evolution as reviewed by Marsh et al. (2011) reveals that this once diverse order was thought to have evolved during the Early Eocene, with several, often sympatric, Sirenian genera and species inhabiting the extensive shallow coastal waters of the Tethyan Seaway. The Dugongidae evolved in the Middle Eocene and spread through what are now the coasts of the Mediterranean, Europe, North Africa, western Atlantic–Caribbean, Indian and Pacific Oceans (Marsh et al., 2011; Velez-Juarbe et al., 2012). Although still widespread across the Indo-Pacific, including most of the Coral Triangle and in particular small island groups east of the Wallace Line, extant dugong populations are thus thought to be relicts of a once much larger and widespread population (Marsh et al., 2011).

Unlike their closest living relatives, the manatees (Trichechidae), which can also feed on freshwater vegetation, dugongs depend almost exclusively on seagrass ecosystems for food (Preen, 1992, 1995b; Erftemeijer et al., 1993), and seagrass meadows are the principal habitat of dugongs throughout their life-cycle (Marsh et al., 2011). Dugongs can migrate considerable distances (Sheppard et al., 2006; Sheppard, 2008), and are known to rest and take refuge from predators or storms in other habitats, including coral reefs (Marsh et al., 2011). The ecological links between dugongs and seagrass meadows are complex and despite recent advances in knowledge are still not fully understood (de Iongh et al., 2007; Marsh et al., 2011); however, there is substantial evidence that mega-herbivores, such as green turtles (*Chelonia mydas*) and dugongs, can play important ecological roles (Aragones et al., 2006, 2012a; Burkholder et al., 2013; Heithaus et al., 2014). Examples include bioturbation during feeding on seagrasses (Heinsohn et al., 1977); increased microbial nutrient re-cycling after excavation (Perry and Dennison, 1999); influence on seagrass species composition and nutrient content (Preen, 1992, 1995a; Aragones and Marsh, 2000; Aragones et al., 2006); promotion of seagrass growth through fertilization by dugong feces and increased seagrass productivity post-grazing (McMahon, 2005); and the potential for seed and propagule dispersion (Kendrick et al., 2012).

From an anthropologic perspective, many cultures have special relations with the dugong. These can be both exploitative and cultural, including rites and rituals associated with dugong hunting and use, arts and crafts, myths and folklore, and even quasi-religious beliefs (Nair et al., 1975; McNiven and Feldman, 2003; Hines et al., 2005; Adulyanukosol et al., 2010). Lui et al. (2016) highlight the role dugong and turtle “bushmeat” can play in maintaining cultural identity and social capital,

maintaining links between people living in a modern (urbanized) environment and their traditional cultural roots. Exploitative uses reported in the review by Marsh et al. (2011) include the consumption of dugong meat and offal; the production of aphrodisiacs, love potions, folk medicines, and other charms from dugong tears and body parts including genital organs, teeth, bones, and flukes; the carving of dugong bones to make toys, tools, ornaments and works of art; and the use of dugong oil for cooking, lighting and lubrication.

Based on both ecological and socio-cultural considerations, as outlined above, there is ample evidence that dugongs can play an important role in small island socio-ecological systems. Furthermore, within the Indo-Pacific region, the dugong can arguably be considered as a keystone species in tropical seagrass ecosystems. The biological and ecological characteristics of dugongs make them intrinsically vulnerable to extirpation, i.e., local or regional extinction (Marsh et al., 2011). As “K-strategists” with few predators (other than mankind), dugongs have evolved traits (e.g., long lifespan—up to 73 years; slow physical development and long time to sexual maturity—can be 10–15 years; small litters—one calf; long parental care and inter-pregnancy intervals) that enable them to maintain relatively stable populations close to the carrying capacity of their environment and making them generally poor colonizers of new habitats (Reynolds and Marshall, 2012).

The most recent evaluation based on the IUCN Red List criteria (Marsh and Sobtzick, 2015) placed dugongs in the IUCN Vulnerable category, with a cautionary note that data were minimal outside Australia, with strong indications that in recent times dugong populations had declined sharply or been extirpated over a third or more of their Indo-Pacific range. International concern is further evident in the listing of the dugong (excluding Australian populations) in Appendix I of CITES¹ (Convention on the International Trade in Endangered Species of Fauna and Flora).

Within Indonesia, the limited data available at the time were considered sufficient to warrant full protected status for dugongs under law PP No. 7/1999. The dugong is currently one of 20 conservation priority taxa in the 5 year (2014–2019) strategic plan of the Indonesian Ministry for Marine Affairs and Fisheries (MMAF). Estimates of historical and current dugong populations and distribution in Indonesia vary. Marsh et al. (2002) cited a decline in Indonesian dugong population estimates from approximately 10,000 in the 1960’s to approximately 1,000 by the 1980’s, indicating that dugong populations had been reduced to 10% (or less) of their pre-Independence abundance.

Despite the relatively large body of literature on dugongs worldwide (evidenced by the 68 pages of references in Marsh et al., 2011), published data on dugong populations in the archipelagos around Sulawesi are extremely limited. The dugong distribution given in the on-line database for protected species maintained by the Indonesian Ministry of Marine Affairs and Fisheries (Mmaf, 2016), similar to that presented at a seminar entitled “The Dugong” in 1979 (Hendrokusomo et al., 1979), comprises only one Sulawesi province (North Sulawesi). A much

¹<https://cites.org/eng/app/appendices.php>

wider historical dugong distribution around Sulawesi (Whitten et al., 2002) is supported by data on the stomach content of a dugong from the Spermonde Islands (Erftemeijer et al., 1993), sightings in Palu bay (Moore, 2004) and reports of dugong sightings in the Taka Bone Rate and Wakatobi Archipelagos (Marsh et al., 2002).

At a seminar held in Bogor in April 2016², it became evident that data on dugongs and coastal/island community perceptions of and interactions with dugongs had been collected, under various government and academic programs concerned with small island and coastal ecosystems around Sulawesi. Most of these data were unpublished, and thus not readily available to relevant stakeholder groups, in particular those involved in research on and/or the conservation and management of dugongs and their habitat. The threefold purpose of this research was to (i) collect and compile published and unpublished data and information on dugong populations around Sulawesi and human-dugong interactions, especially in small island groups in Central and South Sulawesi Provinces; (ii) identify trends, key issues and gaps in knowledge; (iii) consider the role that dugongs and dugong conservation could or should play in the future of small island socio-ecological systems.

MATERIALS AND METHODS

Scope

The geographical scope of this research was limited to Central Sulawesi and South Sulawesi Provinces in Indonesia, with special focus on five small island groups: the Togeian and Banggai Archipelagos in Central Sulawesi; the Spermonde, Tanakeke and Taka Bone Rate Islands in South Sulawesi Province (**Figure 1**). A map providing additional data on dugong distribution in Central Sulawesi is provided in Supplementary Materials. In terms of subject matter, the focus was as much on interactions between small island communities and dugongs (direct use as well as culture), as on dugong populations (distribution, trends in abundance). Looking to the future, the scope was broadened to consider opportunities for synergy between dugong conservation, small island ecosystem health and human welfare.

Data Collection and Sources

Materials used in this research included published scientific literature, so-called “gray literature” (e.g., project reports submitted to government agencies and non-government organizations, internal research reports), electronic media (web-pages), and unpublished data collected by the authors through personal observation and Participatory Rural Appraisal methods (DFID-SEA, 2002), in particular key informant interviews (KII). The majority of data on dugongs in Central Sulawesi, in particular the Togeian and Banggai Archipelagos, were collected using the KAP (Knowledge, Attitude and Perception) questionnaire (CRITC, 2000) as adapted and used in Central Sulawesi since 2002. The version of the KAP questionnaire used covers three ecosystems (coral reefs, seagrass meadows and

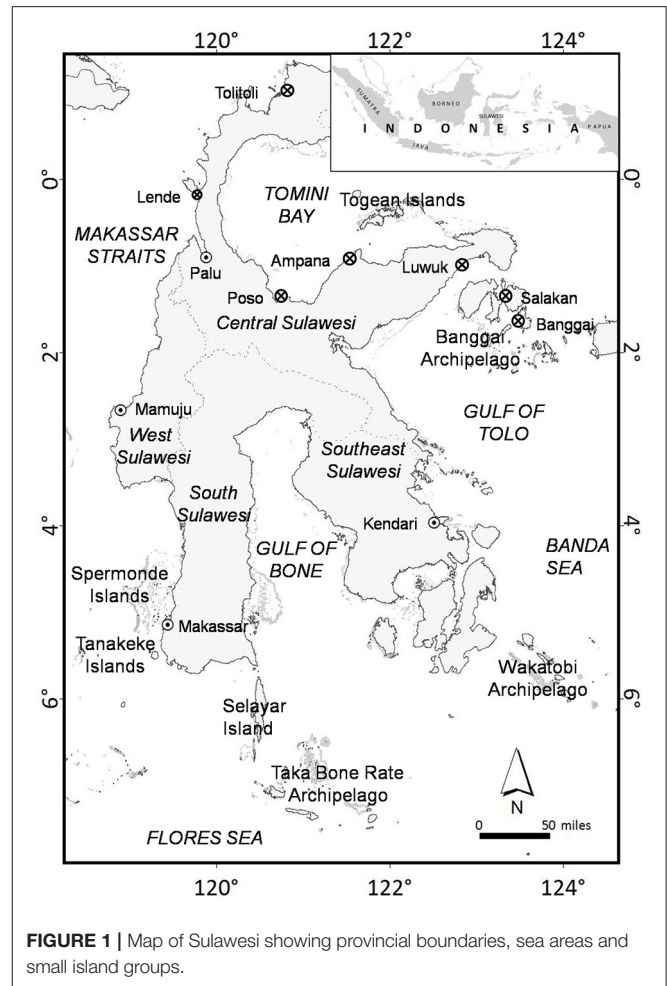


FIGURE 1 | Map of Sulawesi showing provincial boundaries, sea areas and small island groups.

mangrove forests) as well as species protected under Indonesian law (PP No. 9/1999) or other instruments (e.g., CITES), including dugongs. KAP data were collected from the Togeian Islands (2002, 2007, 2015) and Banggai Archipelago (2004, 2006, 2015) as well as several sites on the Sulawesi mainland coast. Details of the main “gray literature” sources (mostly in Bahasa Indonesia) are given in **Table 1**.

Data Analysis

The data collated were not suitable for statistical analysis. Quantitative data (e.g., percentage of respondents in KAP studies) were tabulated. The data were analyzed descriptively and evaluated in the context of dugong conservation, focussing on dugong habitat and populations, as well as cultural importance and exploitation of dugongs.

RESULTS

Dugong Habitat—Small Island Ecosystems (Seagrass and Coral Reefs)

The data in **Table 2** show that destructive practices have been—and still are—common in the shallow water ecosystems of both Central and South Sulawesi Provinces, and in particular around

²Simposium Dugong dan Habitat Lamun. IPB International Convention Center, 20–21 April 2016.

TABLE 1 | Main “gray literature” sources of data on dugongs in Central Sulawesi.

Year	Geographical coverage	Type of study/methods used*	Reference and Original Title	Report Description
2002	Togean Islands, Donggala District (Makassar Straits)	Multi-disciplinary study on coastal resources and livelihoods; Included KAP study	YACL (2002). Laporan Final “Identifikasi Aktifitas Bagi Peningkatan Pendapatan Masyarakat Pesisir Dan Pengelolaan Sumberdaya Pesisir dan Laut di Lokasi MCMA”.	Report by local NGO Yayasan Adi Citra Lestari (YACL) to the Central Sulawesi Province Regional Planning Agency
2003	Parigi-Moutong District	Multi-disciplinary study on aquaculture potential; Included KAP study	YACL (2003). Laporan Final “Penentuan Lokasi Pengembangan Budidaya Perikanan pada Daerah MCMA Kabupaten Parigi Moutong	Report by local NGO YACL to the Central Sulawesi Province Regional Planning Agency
2006	Banggai Archipelago	Sea Partnership survey with special focus on the Banggai cardinalfish; Included KAP study, KII	LP3L Talinti (2006). Laporan Akhir Pendataan Habitat, Populasi dan Pemanfaatan Ikan Hias di Pulau Banggai, Sulawesi Tengah sebagai dasar perencanaan pemanfaatan berkelanjutan secara ekologis dan ekonomis	Report by the local NGO LP3L Talinti to the Central Sulawesi Provincial Marine and Fisheries Agency
2012	Donggala District (Makassar Straits)	Surveys of existing and proposed marine protected areas; Both included KAP studies, KII	LP2M STPL (2012). Survey Sarana Daerah Perlindungan Laut Tanjung Ayuan, Kabupaten Donggala.	Reports by the research and extension unit of the STPL-Palu (LP2M STPL) to the Donggala District Marine and Fisheries Agency
2013			LP2M STPL (2013). Survey dan Identifikasi di SMS Pulau Pasoso dan di Pulau Maputi.	
2014	All Districts in Central Sulawesi	Project to draft a marine conservation roadmap for Central Sulawesi Province; Included KII, FGD	KMB Sulteng (2014). Laporan Akhir Road Map Konservasi Perairan Provinsi Sulawesi Tengah	Central Sulawesi Sea Partnership report to the Central Sulawesi Provincial Marine and Fisheries Agency
2014	Banggai Laut, Banggai and Donggala Districts	Activities related to the initiation of Ecosystem Approach to Fisheries (EAFM) implementation in Indonesia Both included KAP studies, KII, FGD	LC-EAFM STPL-Palu (2014). Penilaian Performa Pengelolaan Perikanan menggunakan Indikator EAFM di Kabupaten Donggala, Kabupaten Banggai dan Banggai Laut.	Project reports by the STPL-Palu EAFM Learning Center (LC-EAFM STPL-Palu) to the World Wide Fund for Nature (WWF) Indonesia
2015	Banggai and Banggai Laut Districts		LC-EAFM STPL-Palu (2015). Ekosistem Pesisir di Kabupaten Banggai dan Banggai Laut	
2015	All Districts in Central Sulawesi	Protected marine species Survey; Included KAP study, KII, FGD	LP2M STPL-Palu (2015). Laporan Akhir Survey Sebaran dan Pemanfaatan Jenis Ikan yang Dilindungi di Sulawesi Tengah.	Report by the STPL-Palu to the Coastal and Marine Resource Management Agency (BPSPL)

*Extracts from each of these reports were used, as well as some additional data collected by the first author during the surveys but not included in the final project reports; KII, key information interview; FGD, focus group discussion; KAP, knowledge, attitude and perception.

all five island groups. Coastal and small island ecosystems, including dugong habitat, have suffered considerable degradation in terms of both condition and extent. In 2016, the reefs around Tanakeke were in poor condition, and destructive fishing was still rife. In Taka Bone Rate the seagrass meadows appeared to be healthy; on the other hand, the predominantly degraded condition and signs of recent damage on the coral reefs corroborated information from respondents that, despite National Park status, destructive fishing had not yet been eliminated. Contrary to the common perception that destructive fishing, especially the use of explosives and poisons such as cyanide, is concentrated in coral reef ecosystems, the data in **Table 3** reveal that, in recent decades, such practices have also been common in seagrass meadows, the main dugong habitat and food source.

Destructive fishing practices in the study areas also included the use of simple “blunt instruments” to break open or overturn corals in search of invertebrates, or to collect the ornamental or food fish stunned by poison fishing. Other fishing

practices considered likely to damage/degrade coral reefs and/or seagrass beds included the use of gill nets that catch on corals and seagrasses which are then pulled up with the net. KAP respondents reported that it was not uncommon for seagrasses (mostly *Enhalus acaroides*) to be cut (*dipangkas*) to reduce difficulty in hauling the nets, especially in certain parts of the Togean Islands.

Despite growing awareness of the ban on coral mining, as well as increased enforcement efforts, the most recent data and observations (2015/2016) revealed that this highly destructive extractive practice was still widespread. Coral mining was a major threat at some KAP sites in each area, despite patchy improvements in enforcement and localized efforts to replace corals with other building materials, not an easy task in terms of small island logistic and economic settings. While community members viewed corals as free (personal use), or a source of income (collecting and selling to projects), many local government officials saw the use of local materials (sand and corals) as the only way to

TABLE 2 | Summary of data on dugong distribution, habitat, abundance, exploitation, legends, and direct sightings by authors by geographic area.

No.	Parameter or Feature recorded/observed (Note: Y = presence; N = definite absence; ? = uncertainty or conflicting data; blank spaces = no data available)	Togean Islands	Banggai Archipelago	Palu Bay	Central Sulawesi West Coast	Tomin Bay mainland coast	Spermonde Islands	Taka Bone Rate Islands	Tanakeke Is.	
1	Direct sightings of Dugongs (alive or freshly killed) by authors			2001			1993	2016	2016	
2	Last reported sighting based on respondent data	2015	2014	2002		2015	1993	2016	2016	
3	Reported as once common (by older respondents)	Y	Y	2015	Y	Y	Y	Y	Y	
4	Sharp decline in past 50 years	Y	Y		Y	Y	Y	Y	Y	
5	Suspected extirpation or biological extinction			Y			Y	N	Y	
6	Dugong population at high risk of extinction due to human activity	Y	Y		Y	Y		Y		
7	Exploitation for meat (consumption)	Y	Y	N	Y	Y		N	Y	
8	Exploitation for sale of body parts (T = tusks; S = skin, O = other)	T,S,O	T,S,O	N	T,S	T,S	O	T	T,S	
9	Dugong tears as love filters/remedies	Y	Y	N	Y	Y	Y	Y		
10	Dugong princess (<i>putri duyung</i>) or other dugong legends/folklore	Y	Y	Y	Y	Y	Y	Y	Y	
11	Destructive fishing in coral reefs (CR) and/or seagrass meadows (SG)	CRSG	CRSG	CR N	CR SG	CR SG	CRSG	CR	CR	
12	Decline in coral reef (CR) and/or seagrass (SG) condition since ≈ 2000	CR SG	CRSG	CRSG	CR SG	CR SG	CR SG			
13	Decline in reef/seagrass associated fish resources since around 2000	Y	Y	Y	Y	Y	Y			
14	Decline in reef/seagrass associated invertebrate resources in past decade		Y	Y			Y			
15	Pollution, including domestic waste (plastics, batteries etc.) & sewage	Y	Y	Y	Y	Y	Y	Y	Y	
16	National Park with management authority and plan, zonation, etc	Y	N	N	N	N	N	Y	N	
17	Presence of small sub-national MPA(s), confirmed or proposed		Y		Y	Y	Y		Y	
18	Dugong population included in national species conservation database	N	N	N	N	N	N	N	N	
19	Dugong conservation initiatives	N	N	N	Y	N	N	Y	N	
20	Cases of dugongs as pets or as visitor attraction	N	N	N	Y	Y	N	Y	N	
21	Sources (*for more details see Table 1)	YACL (2002, 2003)*; LP3L Talinti (2006)*; Ndobe et al. (2005, 2014); Ndobe and Moore (2008); Ndobe (2013); Moore et al. (2014); LC-EAFM STPL-Palu (2014, 2015)*; LP2M STPL-Palu (2015)*								

stay within central government budgetary constraints, while enabling all parties concerned to make a (legal and/or illegal) profit.

Threats to both coral reefs and seagrass meadows included sedimentation due to degradation of terrestrial ecosystems and in some cases mangroves, as well as land based and marine-based pollution, the former mainly domestic waste and sewage, and the latter mainly from the many vessels of all sizes plying the waters around Sulawesi. Signs of climate change impacts, specifically coral bleaching, have also now been recorded in all the islands and coastal areas covered in this research. In 2010, coral bleaching was observed in Tomini Bay (Muslihuddin et al., 2012) and Spermonde Islands (Yusuf and Jompa, 2012), but not Banggai Archipelago or Palu Bay. The 2016 global bleaching event appears to have affected all island groups and many coastal reefs around Sulawesi, including areas not noticeably affected in 2010, such as Palu Bay and the Banggai Archipelago (Jompa, pers.com; Moore, unpublished data).

In addition to widespread defaunation from intensive gleaning observed at most KAP sites, there is some experimental evidence from the Spermonde Islands that trampling during gleaning and other human activities can have a negative effect on seagrasses (Nadiarti, pers. com., 2016), as well as causing mechanical damage to corals. Threats specific to seagrasses include the deliberate cutting or pulling up of seagrasses, mainly *E. acaroides*, considered as a nuisance to fishers (the leaves get caught in gill nets) or seaweed farmers (seagrasses harbor “pests”—herbivorous fishes and invertebrates which feed on the seaweed); and physical damage from boats (anchor damage, dragging scars). Around Tanakeke the villagers have taken up seaweed farming. The villagers consider that the seagrass promotes predation on their seaweed, because many herbivores live in the seagrass. Therefore, they cut or even pull up seagrasses in the seaweed farming areas.

Dugong Populations

Data on dugong distribution, abundance, and exploitation, as well as community knowledge and perception regarding dugongs and the coastal ecosystems they inhabit, are summarized by geographical area in **Table 2**; KAP data are summarized by region and year in **Table 3**; data on six dugong stranding cases are presented in **Table 4**, and are described in greater detail in Supplementary Materials. The most recent reported dugong sighting in the Spermonde Islands was in 1993 when the capture of an adult dugong by fishermen of Barranglombo Island resulted in an impromptu festival. The lack of any sightings since 1993, in an area with relatively heavy boat traffic and frequent marine and fisheries research expeditions, can be considered a strong indication that dugongs have been extirpated in this archipelago.

Close encounters with a lone dugong (sex unknown) in Palu Bay during coral reef surveys in 2001/2002 were reported in Moore (2004). The continued presence of a single dugong in the Bay was corroborated by information from fishermen in 2009 and 2015. Although this dugong is presumably still present, unless it can find a mate within its migratory area, the extent of which is unknown, the Palu Bay population can also be considered biologically extinct. KAP data on dugongs along the west coast

of Central Sulawesi (Makassar Straits and Sulawesi Sea), Tomini Bay and Banggai Archipelago unanimously indicated a continued decline in dugong abundance; however the most recent data indicated that dugongs were still extant in these areas in 2015.

In the Taka Bone Rate, two adult (approximately 2 m long) dugongs were seen (separately) during the Nusantara Jaya Expedition, organized under the maritime youth program of the Coordinating Ministry for Marine Affairs. According to local respondents, six dugongs were often seen in the early morning or late afternoon around Jinato Island.

In Tanakeke, a dugong caught in April 2016 was described as a pregnant female approximately 2 m in length. While 2 m is small for an adult (pregnant) female dugong, it is worth noting that many villagers are still more familiar with non-metric measurement systems, especially the “*depa*” (the length between fingertips of a person extending their arms horizontally to each side, generally around 1.5 m), and thus this 2 m estimate may not be an accurate length. The villagers said that dugongs are getting harder to find, but they generally caught any dugongs they saw, and had recently caught one earlier in 2016. Since April 2016 there have not been any dugong sightings around Tanakeke, and it is likely that the dugongs caught in 2016 were the last two dugongs remaining in this area.

Strandings and accidental captures of both adult and juvenile dugongs (calves) reported in the press (**Table 4**) indicate dugongs are (or were until recently), present in the waters around both South and Central Sulawesi, from Tolitoli in the north (Salut, 2015; Sari, 2016) to the waters around Selayar Island in the south (Syarif, 2011). These events show that, however depleted, in recent times these populations comprised reproductively active individuals of both sexes. Some dugongs stranded or caught as by-catch had been kept in semi-captivity by local people, typically tied by the tail within seagrass meadows (Syarif, 2011; LP2M STPL-Palu, 2015; Salut, 2015; Ederyan and Buatan, pers. com., 2015; Sari, 2016). Where captive dugongs had been released, their subsequent fate was/is unknown.

Dugong Exploitation and Cultural Role—*putri duyung*

The KAP data (**Table 3**) show that the growing (and now ubiquitous) awareness of the protected status and declining dugong abundance had not halted exploitation. Palu Bay was the only site with no history of dugong hunting in recent decades. Although dugong populations were reduced to the point where they could no longer support purposive hunting in all areas surveyed, the Spermonde Islands were the only site where opportunistic capture had ceased, simply because there were no longer any dugongs to catch. As recently as 2015/2016, from the Banggai and Togean Islands in Central Sulawesi to Tanakeke in South Sulawesi, the authors had encountered people who had recently partaken in or expressed support for dugong hunting, as well as people who in principle support dugong conservation, but will readily consume dugong meat when available, whether from accidental or purposive kills, fresh or preserved.

In Taka Bone Rate, the Jinato Island community (Bugis from Sinjai) admitted that they used to consider dugongs as weird

TABLE 3 | Selected data from knowledge, attitude, and perception (KAP) studies by geographical area and year or time period.

No.	West Coast of Central Sulawesi	2002 ¹	2007 ²	2012 ³ /2013 ⁴	2015 ⁵
1	Know at least one seagrass ecosystem function	78%	73%	90%	100%
2	Aware of the protected status of dugongs	0%	100%	100%	100%
3	Seen or know of recent dugong capture and exploitation	Yes	Yes	Yes	Yes
4	Opinion on dugong exploitation (food, sale of body parts, tears)	Considered normal	57% against	100% against	100% against
5	Perceived changes in local dugong population	noticeably reduced	drastically reduced	very few left, at some sites think there may be none left	
6	Sources (for more details on 1,5 see Supplementary Materials)	¹ YACL, 2002	² Ndobe and Moore, 2008;	³ Moore et al., 2014; ⁴ Ndobe et al., 2014	⁵ LP2M STPL-Palu, 2015
No.	Togean Islands/Tomini Bay	2002 ¹	2003 ²	2007 ³	2015 ⁴
1	Know at least one seagrass ecosystem function	70%	100%	73%	100%
2	Aware of the protected status of dugongs	0%	0%	15%	100%
3	Seen or know of recent dugong capture and exploitation	Yes	Yes (for tears)	Yes	Yes
4	Opinion on dugong exploitation (food, sale of body parts, tears)	Considered normal	No opinion	73% against	1 respondent in favor
5	Perceived changes in local dugong population	Less than before, still quite common	Becoming rare	Becoming hard to find	Very rare, risk of extinction
6	Sources (for more details on 1,2,4 see Supplementary Materials)	¹ YACL, 2002	² YACL, 2003	³ Moore, unpublished data	⁴ LP2M STPL-Palu, 2015
No.	Banggai Archipelago	2004 ¹	2006 ²	2011/2012 ^{3,4}	2014 ⁵ /2015 ⁶
1	Know at least one seagrass ecosystem function	50%	100%	100%	100%
2	Aware of the protected status of dugongs	Very few aware	100%	100%	100%
3	Seen or know of recent dugong capture and exploitation	Yes	Yes	Yes	Yes
4	Opinion on dugong exploitation (food, sale of body parts, tears)	Most consider it normal	Don't agree with it	Majority against	Majority against
5	Perceived changes in local dugong population	Few, used to be abundant	Becoming rarer	Becoming rarer	Becoming rarer
6	Sources (for more details on 2,4,5,6 see Table 1)	¹ Ndobe et al., 2005	² LP3L Talinti, 2006	³ Ndobe, 2013; ⁴ LC-EAFM STPL-Palu, 2014	⁵ LC-EAFM STPL-Palu, 2015; ⁶ LP2M STPL-Palu, 2015

creatures (*mahluk aneh*) with supernatural powers or a kind of Jinn (a malicious supernatural being) which should be killed. The villagers used to take and sell the teeth, especially the tusks, but would not eat the meat or make use of other body parts. In 2016, they said that they now realized that dugongs are harmless, and that they enjoy going to watch the dugongs when they come to feed in the clear waters around the village jetty, where green turtles (*C. mydas*) could also frequently be seen grazing in the seagrass meadows. This seemed to be a part of a wider increase in conservation awareness and stewardship of their marine natural resources; marine ecotourism (facilitated by the National Park) was beginning to develop and the villagers also appreciated the increase in once depleted seagrass-associated fishes.

In Tanakeke (Makassar), there were *putri duyung* legends, but those exploiting dugongs said that they did not believe in these legends and considered that dugongs were just like any other fish and fair game. They were aware of the protected status of dugongs, but because the meat was especially delicious they still caught and ate dugongs whenever they had the chance. The

villagers had no fear of enforcement officers or eventual penalties, as no-one had ever been arrested for catching or killing a dugong. According to the respondents, the police are afraid to catch bomb fishers, and do not dare interfere with infractions of laws related to marine resources and conservation. The meat not consumed by the hunters and their families was sold for IDR 30,000/kg (under US \$3/kg), but only within the local community. The hunters kept the skin, but did not say for what purpose, while the teeth/tusks were sold (price not given).

In Barranglompo Island, despite the apparent extirpation of dugongs in the Spermonde Islands, dugong bones can still be seen hung up as decorations. A particularly visible case is the bones hung above the door of a local souvenir/craft shop, whose wares are mostly made from mollusc shells (protected and unprotected species). It is likely that this practice is based on similar superstitions to those reported in Nair et al. (1975), i.e., to ward off bad luck and evil spirits.

Communities in four island groups had *putri duyung* (dugong princess) legends (**Table 1**) in which a human woman is

TABLE 4 | Six Dugong by-catch and stranding cases in Central and South Sulawesi.

Location	Date	Reported sex/size	Brief history	References
Tolitoli District, Central Sulawesi	September 2016	Male; body length 168 cm; body circumference 134 cm	Entangled in fishing net; untangled and tied to a stake by a rope around its tail by the fisherman, purpose unknown; tagged and released by authorities; superficial wounds seemed to have occurred during captivity	Sari, 2016
Donggala District, Central Sulawesi	November 2015	Female calf, around 1 m body length (see Supplementary Materials)	Found stranded with an incompletely healed puncture wound; “rescued” by villagers and tied by the tail; mother possibly a hunting victim; released by government officers	Ederyan and Buatan, pers. Com
Tolitoli District, Central Sulawesi	Around 2006	Sex unknown; very small, possibly neonate	Entangled in fishing net. Reared in captivity and kept by the fisherman and his wife for 9 years; released by authorities in 2015, at around 2 m in length	Salut, 2015
Tomini Bay, Central Sulawesi	2015	Sex unknown; around 1 m long and 40 kg in weight	Washed up (stranded), very weak and reportedly attacked by schools of small fish; local people attempted to return the calf to the sea, but for a long time it kept returning to shore	Wartabone, 2015
Tomini Bay, Central Sulawesi	Unknown	Sex unknown; size unknown	Kept captive (tied by the tail and regularly moved to fresh seagrass) for many years as a pet and a source of income (visitor fees); released by the authorities in early 2015;	LP2M STPL-Palu, 2015
Selayar Island, South Sulawesi	January 2011	Sex unknown; photographs indicate young calf	Stranded, reportedly with blood-sucking animals attached; initial attempts to return the calf to sea failed; kept tied by the tail by a fisherman; became an (unpaid) attraction and gave rise to fears rooted in local superstitions; eventually released	Syarif, 2011

transformed into a dugong. Despite local differences, all had a common theme of close kinship between fishing communities and dugongs, and most contained some form of injunction to be careful of or refrain from harming or killing dugongs. This relationship is somewhat ambivalent, as in some versions of the legends, the *putri duyung* ends up being killed and eaten, albeit with ritual trappings.

In several areas, instances of dugongs kept as pets or keeping them captive as an income-generating attraction had been observed or reported (see Supplementary Material). The dugongs involved were initially stranded or unintentionally caught in nets, sometimes with evident wounds, and mostly juveniles at the time of rescue and adoption (Tables 2, 4; see Supplementary Material). These cases could indicate a spontaneous readiness of at least some fishing families and their communities to engage in dugong conservation.

Both dugong and dolphin tears were widely believed to have magical properties, in particular as love filters and to ward off evil spells; in some cases they were also believed to have curative properties. According to respondents, the collection of dugong tears involved the capture and (usually but not always) subsequent release of a dugong (or dolphin), often a juvenile. Although dugongs naturally produce “tears” when out of the water for any length of time (Lanyon et al., 2010; Marsh et al., 2011), in Central Sulawesi at least it seemed to be common practice to beat dugongs (or dolphins) about the head, with the goal of further stimulating tear production.

DISCUSSION

Threats to Dugongs and Their Habitat

Threats to dugong in the small islands around Sulawesi comprise most, possibly all, of the four major threat types listed by

Marsh et al. (2002, 2011) for dugong populations worldwide. These include degradation/loss of seagrass habitat (widespread); accidental by-catch (dugongs become tangled in nets and seaweed lines); hunting (an ongoing major threat); and possibly boat collisions. The latter is probably a relatively minor concern in most of the study area, but could be an issue near busy ports (e.g., around Makassar, in Tolitoli and Palu Bays), especially should dugong populations begin to recover. The first three threats are considered below.

Habitat Loss/Degradation

At a global level, the loss and degradation of seagrass meadows is a significant threat to seagrass-associated species, including dugongs (Hughes et al., 2009; Waycott et al., 2009). Although most sites with data on destructive fishing in seagrass beds were in Central Sulawesi (Table 2), it is likely that such practices occur over a much wider area within the three seas where the KAP study sites were situated, i.e., the Makassar Straits, Tomini Bay and Gulf of Tolo/Banda Sea. The cutting or pulling up of seagrasses was reported from islands and coastal areas in both provinces. Clearly seagrass conservation is an important issue in the small islands of South and Central Sulawesi. The Jinato Island case demonstrates that seagrass ecosystem conservation can be achieved and can benefit island communities.

Accidental Capture (By-Catch)

Our data confirm that the remaining dugongs around Sulawesi are at risk of accidental capture in fishing gear. The Convention on the Conservation of Migratory Species of Wild Animals (CMS)³ and the Dugong and Seagrass Conservation Project⁴ have highlighted dugong by-catch as a major concern, and one of

³<http://www.cms.int/dugong/en>.

⁴<http://www.dugongconservation.org>.

the main causes of dugong mortality. Although the reported cases of “by-catch” described in this paper mostly resulted in dugongs being released alive, it is not known whether or not they survived thereafter. Data from KAP surveys and other interviews do make it very clear that not all dugongs snagged in seaweed lines or caught in fishing nets would be released. Such dugongs would stand a high risk of being killed; as for dugongs actually hunted (see below), the meat would then be eaten, and other body parts sold. Similar behavior of fishers with respect to dugong by-catch has been reported from other areas in Indonesia and more widely in Asia (Aragones et al., 2006; Hines, 2012a). This is one area where research could contribute to conservation, for example through developing fishing gear or practices which minimize the risk of dugong by-catch, while awareness and education could improve the outcomes in terms of short and long-term survival of the dugongs caught.

Hunting and Exploitation

The situation around Sulawesi as indicated by our data refutes the statement in Hines (2012a) that “in Indonesia, apart from the Aru Islands, there are no reports of dugongs being actively hunted”. The data presented in **Tables 2, 3** provide evidence of continued dugong hunting around Sulawesi, despite growing awareness of the protected status and declining populations of dugongs. Clearly socialization has been successful in raising knowledge levels in coastal communities, but in most small island and coastal areas has as yet had little impact on the actions of the (relatively few) people who hunt dugongs for food or for economic gain, or trade in dugong body parts and/or dugong tears.

There was substantial evidence that even people who in principle do not support dugong hunting will readily consume dugong meat. One reason given was that the taste of dugong meat is considered particularly delicious, more so than other red meats, such as beef or goat. Hines et al. (2005) and Adulyanukosol et al. (2010) report a similar preference on the part of Thai coastal villagers. When available, our data indicate that dugong meat may also be more affordable than red meat, such as beef or goat. Meat is relatively expensive in Indonesia, with prices per kg much higher than in many developed countries. The selling price of IDR 30,000/kg (under US \$3) in Tanakeke would be less than a third of alternative red meats (generally US \$10/kg or more), and is comparable to the value of US\$2/kg reported from Cambodia by Hines et al. (2008).

The epicurean aspect is exemplified in the impromptu feast at which the last dugong recorded in the Spermonde was consumed. Of the other two South Sulawesi island groups, the Taka Bone Rate was the only site where dugongs were not eaten, due to local superstitions; in contrast, the Tanakeke Islands were unusual in that meat for human consumption was given as the prime reason for dugong hunting. In some small islands, red meat can be very rare. In Central Sulawesi KAP sites, in particular in the Togeian and Banggai Islands, some of the dugong meat was generally consumed while fresh; the remainder was processed into *dendeng*, a form of dried meat, and shared among members of the island community, as a welcome change from the staple diet of fish and marine invertebrates. The use of dugong body

parts other than meat also varied between sites, and could be related to ethnicity and to market opportunities (sales to traders from outside the community). Bajo (sea gypsy) community members in Central Sulawesi told of similar uses and beliefs to Bajo people in Thailand, as reported by Hines et al. (2005) and Adulyanukosol et al. (2010). The still strong belief in dugong tears as a love filter, and the belief in dugong teeth, especially tusks, as magic charms to ward off evil spirits, are also reminiscent of the situation in Sabah, Malaysia, as reported by Rajamani et al. (2006).

Dugong teeth, especially the tusks, were the prime motive for dugong hunting according to respondents in Central Sulawesi KAP sites and the main dugong product formerly sold from the Taka Bone Rate Archipelago. Both KAP and KII data indicate that, because of their high market value, dugong tusks are rarely kept by fishermen/hunters. One tusk could fetch over IDR 1 million in 2002 (then worth over US\$ 100) in the Togeian Islands, equivalent to several months average net income (around US\$ 30–40); although actual prices were not given by most respondents, order-of-magnitude responses in more recent surveys in Central Sulawesi ranged from 2 to 6 months income, and dugong tusks were also considered to have a high value in South Sulawesi sites. Albeit somewhat higher in relative terms, our data are still comparable to figures reported from Cambodia by Hines et al. (2008), where the average monthly income of fishermen was around US\$ 75, and a pair of dugong tusks could fetch US\$ 100–150.

Surveys in Bali in 2013 and 2014 (Lee and Nijman, 2015) give prices of \$10–\$150 for various dugong parts, including teeth (not tusks) and bones, raw or carved. This is well below the values according to respondents in Central Sulawesi. However, the presence of these items in Bali is consonant with the statements of many KAP respondents from 2002 to 2015 that dugong skin and bones (as well as teeth/tusks) were sold to Balinese traders, though they had no idea what the skin and bones could or would be used for. It is likely that some of the bones at least are also used in traditional remedies, particularly Chinese medicine, as in other Southeast Asian countries such as Thailand (Hines et al., 2005) and Malaysia (Rajamani et al., 2006).

Lee and Nijman (2015) note that law enforcement on dugong products in Bali was effectively non-existent, with one raid (in 2007) resulting in the confiscation of some goods, but no prosecutions. This is similar to the situation in Central and South Sulawesi, where products from many protected species are still made and sold openly, e.g., artifacts from hawksbill turtle shell (*Eretmochelys imbricata*), black coral (*Antipathes* sp.), and the shells of all protected molluscs. It has been reported that in other areas of Indonesia, dugong bones are kept in houses or elsewhere in villages for protection or good luck (Hines, 2012a). Although, the cultural reasons were not clear, in the Spermonde Archipelago dugong bones have been displayed with impunity. Fear of prosecution for hunting/killing dugongs or trading in dugong body parts was not an issue in any of the areas where dugongs were still being hunted. It is abundantly clear that the legislation and regulations protecting dugongs are not being applied. Given the logistical challenges, minimal resources and socio-political environment in small island and coastal areas, it

is hard to see how law enforcement alone could prevent the hunting of dugongs; nevertheless, efforts to stop, or at least reduce, the open trade in (theoretically) protected endangered marine species could reduce the incentives.

Dugong Folklore

The very name of the Order Sirenia is redolent with mythical associations, as recorded in the *Odyssey*, a justly famed masterpiece of Ancient Greek literature. There is an extensive body of popular and scholarly literature linking mermaid/merman and similar legends around the world to Sirenians (e.g., Waugh, 1960; Kemble, 1992; Adulyanukosol et al., 2010; Brito, 2013). In Indonesia, the local name for mermaids, *putri duyung* (dugong princess), reflects this association, and legends abound with common recurring themes, including shape-changing, magic, and morality-related “fable” elements (Nontji, 2015).

Most dugong legends recounted by respondents around Sulawesi were similar to those reported from other areas of Indonesia, and more widely in Southeast Asia, in particular in Thailand (Adulyanukosol et al., 2010). In general, these present an empathic image of dugongs, as closely related to humans, and tend to emphasize the virtue of motherly love as exemplified by the strong ties between mother dugongs and their calf. This is in stark contrast to the Taka Bone Rate perception of dugongs as jinns (*djin*) or weird beings (*mahluk aneh*) potentially threatening to humans. Local beliefs in supernatural powers associated with dugongs were also mentioned in the report on a dugong stranding case in nearby Selayar Island (Syarif, 2011).

While in many communities *putri duyung* legends could form an entry point for conservation of dugongs and their habitat, as has been demonstrated in Thailand (Hines et al., 2005; Adulyanukosol et al., 2010; Aragones et al., 2012b), the change in attitude of the Jinato island community shows that, even where traditional attitudes seem uncondusive, small island communities can change. It also shows that island families can benefit from protecting dugongs and their seagrass habitat in material terms (e.g., improved seagrass fisheries, tourism) as well as in non-material ways (e.g., enjoyment of dugong watching as a recreation).

Dugong Status—The “Lost Princess”

The “lost princess” of the title refers to the apparent extirpation of dugongs in the Spermonde Islands in 1993. However, dugongs may already have been extirpated from Tanakeke, and if current trends continue this title will soon be just as apposite in several other small island groups and along much of the Sulawesi mainland coastline.

With a maximum annual population growth rate of less than 6% (Reynolds and Marshall, 2012), and greatly depleted populations, even low levels of exploitation present a major threat to dugong populations around Sulawesi. While preventing anthropogenic mortality is clearly essential to maintain the remaining dugong populations in Central and South Sulawesi, even under effective full protection their future may be in jeopardy simply because there may already be too few animals, and those which remain may not be viable in terms of

reproductive potential. Adult dugongs may be unable to find a mate, reproduction may not be able to keep pace with or exceed natural and accidental or stochastic mortality. Additionally, the gene pool could be too small, leading to a genetic bottleneck, possible inbreeding and reduced fitness, and increasing the likelihood of extinction (Burger and Lynch, 1995).

Dugong mating patterns seem to be highly variable. Reviews on this topic by Anderson (2002) and Marsh et al. (2011) concluded that dugongs can exhibit lek mating or scramble promiscuity, with empirical support for the theory that mating patterns may depend on a combination of population density and habitat quality, and serial monogamy may occur when population densities are low. This plasticity provides some hope that, if exploitation can be prevented, the remaining dugongs may be able to reproduce and eventually populations could be rebuilt. Reports of dugong calves stranded or caught as by-catch in the past 5 years indicate that, until very recently, dugongs in several areas around Sulawesi have been able to find mates. On the other hand, dugong mothers will not normally abandon a calf, and it is highly likely these were orphans and thus that their mothers have been lost to the reproductive population.

There are currently no data on dugong migrations, home ranges, or other indicators of population connectivity within or between the islands and coastal areas around Sulawesi; therefore, the number of reproductively isolated populations is unknown. Dugong migration patterns vary across their distribution, indicating behavioral plasticity, with apparent migratory ranges from dozens to hundreds of kilometers, and evidence that dugong mothers play a role in passing down knowledge of feeding grounds and migratory behavior to their offspring (Sheppard et al., 2006; Marsh et al., 2011; Seddon et al., 2014). The apparent site fidelity of dugongs around Jinato Island in the Taka Bone Rate Archipelago, South Sulawesi, and in Palu Bay, Central Sulawesi indicate that dugongs living around Sulawesi may not range as far as, for example, some dugongs in Australia. Individual behavior seems variable both within and between dugong populations, and can play a key role in determining genetic population structure (Seddon et al., 2014; Cope et al., 2015). It is the outliers which provide at least a slim hope that dugongs could eventually return to habitat from which they have been extirpated, should still extant populations begin to recover.

The future of dugongs around Sulawesi is by no means certain, even under optimal conditions in terms of community attitude and political will. In order to evaluate the chances of saving or bringing back the “lost princess” and produce realistic long-term conservation plans, quantitative as well as qualitative data are needed. These include data on remaining dugong demographics, including numbers, age and sex, geographical distribution and ranges. Connectivity between island groups and along coasts and genetic diversity are also important factors, as are habitat condition and trends.

Using traditional survey methods, collecting such data would be a mammoth task. The use of modern technologies such as aerial surveys using manned aircraft (Ponnampalam et al., 2015), remote-controlled un-manned drones (Hodgson et al., 2013), tagging (Sheppard et al., 2006, 2010; Marmontel et al., 2012), and underwater acoustics (Ichikawa et al., 2006) or a

combination of these methods (Zeh et al., 2015), which can be used to detect dugong presence, estimate abundance, identify individuals and observe dugong behavior, might be hard to justify for small and scattered dugong populations around Sulawesi. Molecular biology provides tools for assessing connectivity and genetic diversity, and has been applied in dugong conservation programmes (Tikel, 1997; Lanyon et al., 2002, 2009; McDonald, 2005; Blair et al., 2014; Seddon et al., 2014; Cope et al., 2015), although the effort and costs involved might also prove prohibitive.

Citizen science programs, such as the Indonesian SiDidi network (Mmaf, 2016) for reporting protected species sightings via the now ubiquitous mobile phones—could potentially provide valuable data and information. Based on the decision chart developed by the UNEP/CMS (Pilcher, pers. com., 2017⁵; see <http://www.conservation.tools/>), arguably the most efficient and effective method for obtaining relevant data to support dugong conservation around Sulawesi would be the Standardized Dugong Catch / Bycatch Questionnaire, freely available online from the Convention on the Conservation of Migratory Species of Wild Animals (CMS) website⁶, together with a user manual (Pilcher and Kwan, 2012). This tool could be applied to enable relatively low-cost dedicated surveys and as an additional activity during other socio-economic and/or biophysical surveys in relevant areas.

Orphaned Dugongs: Policy Issues and Conservation Potential

The juvenile dugongs stranded around Sulawesi in recent years were probably very young, at most a few months old. Based on a review of data on dugong neonates in Marsh et al. (2011), body length at birth is 1–1.3 m long, with a birth weight of 25–35 kg. Although dugongs can graze very soon after birth, they generally suckle for approximately 2 years and rely heavily on their mothers for protection and to learn appropriate behaviors (Anderson, 1981; Marsh, 1988; Wirsing et al., 2007). In addition to predation by sharks (Wirsing et al., 2007; Marsh et al., 2011), even schools of small fish can harass and be a threat to such young animals, causing significant wounds, as in the stranding case (Table 4; Supplementary Materials) reported by Wartabone (2015). The data in Table 4 show that, while some dugongs released (e.g., in Tolitoli and Poso) were adults and presumably fit to fend for themselves, others were young or very young calves, and in some cases were also wounded (e.g., the Donggala case). Thus, the well-intentioned and increasingly highly publicized release of these juvenile dugongs into the wild, perceived by line agencies as mandatory under current legislation, is very likely a death sentence.

There is clearly a need to review current policies on stranded juvenile dugongs. In view of the critical condition of dugong populations, even one avoidable dugong death is a matter for

concern. As stated by Trouwborst (2013), “where a stricken animal is encountered, the competent authorities or other actors involved may either refrain from interference, attempt to solve the apparent problem in situ [...], euthanize the unfortunate individual, or capture it [...]. If an animal is captured, several outcomes are again conceivable, including euthanasia, permanent captivity or release.” They also point out that such choices are often fraught with complex legal and ethical issues; in particular, while the “mercy killing” of a wild animal with no chance of survival might often be acceptable from a legal standpoint, and could be the most appropriate solution in some cases, the euthanasia of “charismatic megafauna” such as marine mammals can be a (potentially highly) controversial issue. One possible alternative, where coastal communities are willing to care for orphaned dugongs, could be rearing in semi-captivity rather than release, with guidance from scientists and other relevant experts. Coastal villagers have already successfully reared young dugong calves to adulthood in Central Sulawesi, albeit in possibly sub-optimal conditions (see Table 4 and Supplementary Materials). Such a process, involving community stakeholders and dugong experts, could have significant awareness-raising potential as well as possible economic benefits. An inspirational quote from Aragones et al. (2012b), describing what happened after the finding of an orphaned dugong in Thailand, demonstrates the feasibility of such an approach:

“People came to see the tamed calf and learn about dugongs and seagrass beds. The communities realized that they could increase their income with ecotourism programs involving dugongs and seagrass beds. They also learned how dugongs play an important role in a seagrass ecosystem and consequently used the dugong as a flagship species symbolizing the prohibition of fishing gear that destroyed seagrass. The livelihood of the communities soon began to improve because they earned more income from the local fishery inside the now protected seagrass beds. The communities valued the dugongs because of the success of the community-based sea-grass conservation.”

Quo Vadis putri duyung?

There is little doubt that without change, under current threat levels and trends, the future of most dugong populations around Sulawesi is extremely precarious. The question then arises as to whether we can prevent further extirpations. Is saving our dugongs possible, and if so, would it be a wise use of limited conservation resources? To seek an answer to these questions, we need to look beyond the (lack of) scientific data and the ecological role of dugongs, and take a holistic view of the small island socio-ecological system. Like the dugongs, without change, many of the small islands themselves, and the human communities living on them, are at increasing risk. Changes in human behavior patterns are widely accepted to pass through cognitive (knowledge/understanding) and affective (awareness/valuing/caring) processes before the motoric (action) stage occurs. In this context, dugongs could play a crucial role as “Flagship Species”, *sensu* Hines (2012b).

⁵Presented at the training session on dugong and seagrass survey methods (*Pelatihan Metode Survei dan Pemantauan untuk Dugong dan Habitat Lamun*) held at the Indonesian Institute for Science (LIPI) from 30 January–1 February 2017.

⁶<http://www.cms.int/dugong/en/document/standardized-dugong-questionnaire>.

Most ethnic groups in the small islands around Sulawesi, like several peoples across the Asia-Pacific region (e.g., Palau, see Mathews, 2003), have dugong princess (*putri duyung*) legends with a sense of relatedness between humans and dugongs at their core. Like much traditional culture, in some places these legends are in danger of being lost under the tidal wave of modernity sweeping the region. Nonetheless, they still have a powerful appeal, and have the potential to serve as an entry point for changing mindsets, especially among the younger generation, leading to changes in behavior. Coupled with information on dugong life-history and ecology, these can provide a base for both affective and cognitive awareness building, which could be further reinforced by practical actions, such as in the Thailand dugong calf case. Further guidance and inspiration could be sourced from the UNEP/CMS Dugong, Seagrass and Coastal Communities Initiative.

To save the remaining dugongs, and eventually bring back the “lost princesses” where extirpated, would not be an easy task. Stopping exploitation is arguably the most urgent priority, but long-term success would also require preventing or reversing degradation of their seagrass habitat. In turn, this would mean looking after the reefs which protect the islands—and thus the habitat of both dugongs and people. To inspire a sea-change, we propose a vision: dugongs as an iconic symbol of the age-old relationship between mankind and the sea; their very existence a measure of success in achieving responsible stewardship and sustainable small island development.

ETHICS STATEMENT

The authors hereby declare that (i) formal ethics approval was not needed for this study as per institutional guidelines and national laws and regulations; (ii) that no research was conducted on dugongs and hence no ethics approval from an Animal Care and Ethics Committee was needed; and that (iii) the component of our research involving human subjects/informants (in this case interview/questionnaire respondents) was conducted in line with good research practices in Indonesia (for non-medical research), and adhered to guidelines including the following principles:

- (a) The researcher shall obtain prior informed consent (orally) from the informants.
- (b) The researcher shall inform the informants that participation in the study is completely voluntary and that they may choose to withdraw at any time.

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- (c) It shall be clearly stated that participation or refusal to participate does not impair any existing relationship between the participants and any other institutions or people involved.
- (d) It shall be clearly stated (and implemented) that the researcher will avoid including information that may identify the informant in any publication, and that, if at any time informants are concerned about what they were saying being disclosed, they may feel free to stop the interview.
- (e) In case any questions and/or concerns may arise after the study, contact details of the researcher shall be offered and given to the informants.

AUTHOR CONTRIBUTIONS

AM: contributed data from Central Sulawesi (Togean and Banggai Archipelagos), took part in the research process, lead role in manuscript preparation and writing. RA: contributed data from the Spermonde Islands, took part in the research process, manuscript preparation, writing and editing. YA: contributed data from Tanakeke Islands and Taka Bone Rate Archipelago, took part in the research process and manuscript preparation.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <http://journal.frontiersin.org/article/10.3389/fmars.2017.00284/full#supplementary-material>

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