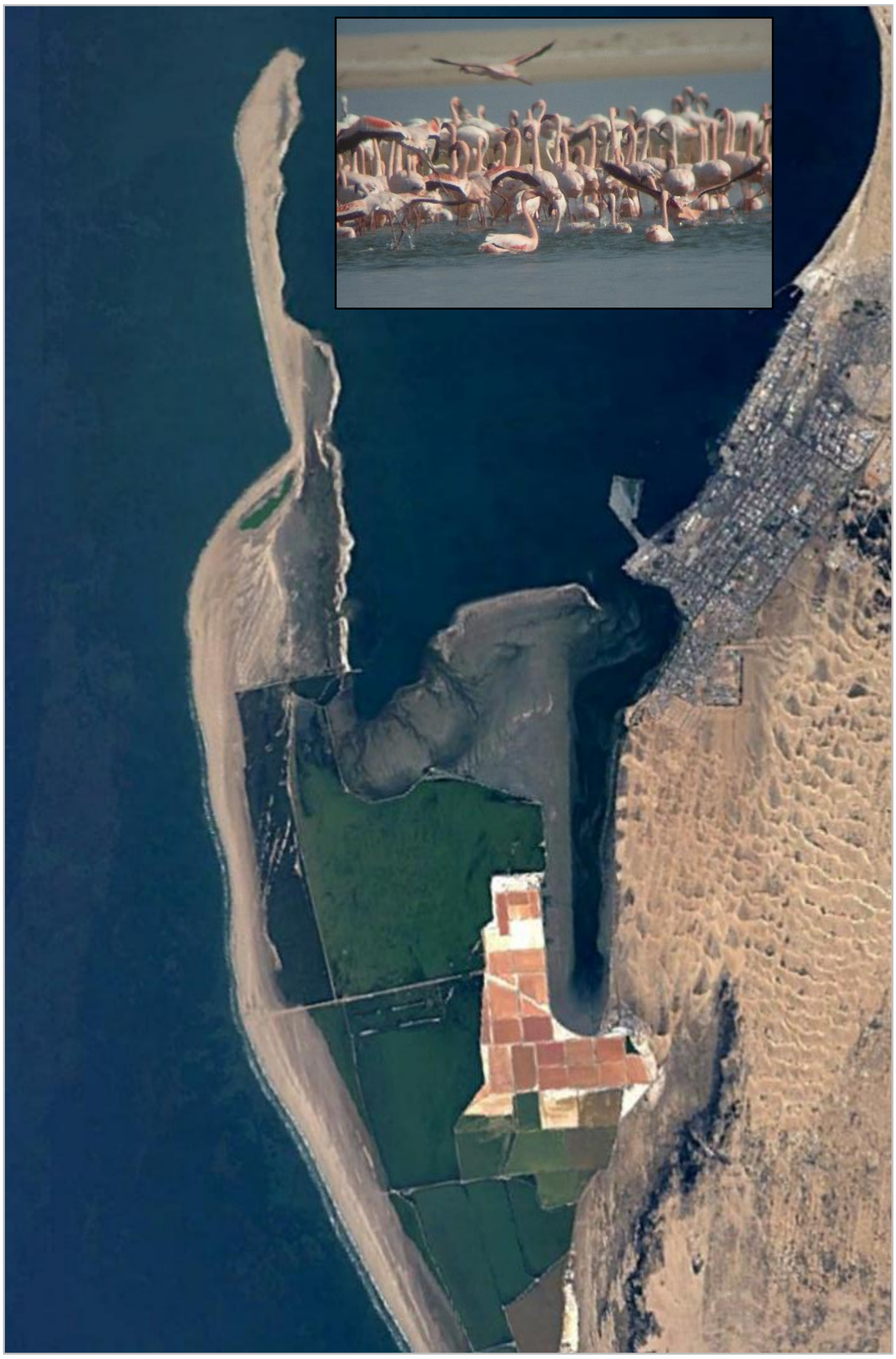
WALVIS BAY – WATERFRONT DEVELOPMENT:

POTENTIAL EFFECTS ON BIRDS OF THE RAMSAR SITE



Prepared for: ENVIRONMENTAL COMPLIANCE CONSULTANCY

Prepared by: BIRDS & BATS UNLIMITED Environmental Consultants www.birds-and-bats-unlimited.com

1 INTRODUCTION

The Walvis Bay waterfront and marina is a new development proposed by Walvis Bay Waterfront (Pty) Ltd in 2017, on the edge of the mouth of the Walvis Bay lagoon. Walvis Bay is a natural embayment on the edge of the Namib Desert that is a wetland, internationally renowned for its diversity and abundance of coastal birds. It holds the single largest accumulation of coastal birds in southern Africa, as well as large numbers of cetaceans (Williams 1983, Wearne and Underhill 2005). As such it was proclaimed a Ramsar Wetland of International Importance in 1995, and is also ranked internationally as an Important Bird (IBA) by Birdlife International (Simmons et al. 1998).

The study of the impacts on the avifauna is triggered under Namibia's Environmental Management Act of 2007 (EMA) and the EIA specifically addresses the effects that the new marina and waterfront development will have on the avifauna of Walvis Bay. The report also provides mitigation measures and alternatives where these are deemed necessary to avoid high impacts.

The development is not large, relative to other on-going construction in the Walvis Bay environs, but it may impact on the mouth leading into the lagoon. The lagoon is already under pressure from wind-blown sediment from the east and increasing organic material accreting in the southern sections.

This report focusses on the effects that the marina itself will have on the prolific birdlife of the area, both within the immediate environs around the marina and waterfront (e.g. noise, light pollution), and "downstream" in the lagoon where sedimentation is a challenge to the long-term future of the lagoon.

Thirty years of twice-yearly bird counts are available from the 1980s to determine long-term avian trends (Wearne and Underhill 2005, Simmons et al. 2015). We also use the fact that the new Walvis Bay container port, under construction since January 2015, may reduce water flow and increase sedimentation in the lagoon. If this affects the birds using the lagoon we should detect a decrease in avian abundance or species diversity in a before-and-after comparison either side of January 2015. This is a report of our findings.

Overall migrant birds have been declining in abundance, while resident and intra-African migrant are stable, or increasing, at Walvis Bay over 30 years.

Depending on the configuration of the protective breakwater for the marina mouth, the flow of the main channel may be intersected, increasing sedimentation down-stream.

1.1 Consultant's Declaration of Independence

Birds & Bats Unlimited are independent consultants to Environmental Compliance Consultancy (Pty) Ltd. They have no business - financial, personal or other interest in the activity, application or appeal other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialists performing such work.

1.2 Qualifications of Specialist Consultant

Birds & Bats Unlimited Environmental Consultants (http://www.birds-and-bats-unlimited.com/), were approached to undertake the specialist avifaunal assessment for the proposed Walvis Bay waterfront and marina and its potential effects on the Ramsar site. Dr Rob Simmons is an ornithologist, with 35 years' experience in avian research and impact assessment work. He was Namibia's state ornithologist for 14 years heading up the research and conservation on wetland and endemic birds, culminating in the first Namibian Red Data book on birds in 2015. He has published over 100 peer-reviewed papers and 2 books, (see http://www.fitzpatrick.uct.ac.za/fitz/staff/research/simmons for details). More than 64 projects and assessments over 23 habitats have been undertaken throughout Namibia, South Africa and Lesotho. He also undertakes long-term research on threatened species (raptors, flamingos and terns) and predators (cats) at the FitzPatrick Institute, UCT.

Marlei Martins, co-director of Birds & Bats Unlimited, has over 6 years' consultancy experience in avian wind farm impacts as well as 20 years in environmental issues and rehabilitation. She has been employed by several consultancy companies throughout South Africa because of her expertise in this field. She has published papers on her observations including a new species of raptor to South Africa (http://www.birds-and-bats-unlimited.com/).

2 TERMS OF REFERENCE

The desk-top study and research includes the following components (as sent by Jessica Mooney of Environmental Compliance Consultancy, 16 March 2017)

- An overview of birds likely to be encountered in the Walvis Bay area including Palaearctic migrant birds;
- A discussion of the potential environmental impact of the construction of the proposed waterfront on said birds, along with suggested mitigation measures;

- The potential environmental impact of prospective daily operational activities associated with the completed waterfront development on said birds, along with suggested mitigation measures;
- MET requests that the study addresses the impacts of lights on the birds in the lagoon and provide alternatives;
- Impacts to the food sources for bird life (e.g. plant life, algae, fish etc.);
- The potential environmental impacts of the waterfront on the RAMSAR site, and
- Any other impacts that may be identified that should be included.

2.1 Need for Proposed Avian Assessment

Birds are known to be impacted directly and indirectly by developments, particularly those around wetlands that are often centers of biological diversity in Namibia (Breen 1991, Barnard 1998). Walvis Bay, the focus of this report, is internationally recognized for its birdlife, and is a proclaimed Ramsar site, and an important bird area (IBA). As such, the development of a waterfront marina triggers an Environmental Impact Assessment under the EMA of 2007, to determine the impacts of the development on the avifauna of the Ramsar site. The Environmental Management Act (2007) promulgated in December 2007 falls under the jurisdiction of the Directorate of Environmental Affairs (DEA), in the Ministry of the Environment and Tourism. Its objectives are to (i) ensure that the significant effects of activities on the environment are considered carefully and timeously; (ii) ensure that there are opportunities for timeous participation by interested and affected parties throughout the assessment process; and (iii) ensure that findings are taken into account before any decision is made in respect of activities.

3 BACKGROUND TO WALVIS BAY AS A BIRD-RICH WETLAND

Walvis Bay is a natural embayment of approximately 70 km^2 in extent on the arid Namib desert coast that holds hundreds of thousands of wetland birds in summer and winter. It vies with Sandwich Harbour (55 km south) as the single-most important wetland in southern Africa in terms of avian biomass and diversity (Williams 1987, Simmons et al. 1998, Wearne and Underhill 2005). The reasons for this can be traced to one of the world's strongest upwelling cells (Sakko 1998) that bring nutrient-rich waters into the protected bay twice a day. The entire central coast benefits from these upwellings (at their most powerful in Lüderitz) because of on-shore winds at certain times of year, and the long-shore Benguela currents that bring the nutrient-rich water from the south (Simmons 1997, Molloy and

Reinikainen 2003). This increases primary productivity in these areas and supports a rich and abundant avian birdlife dominated by wading birds.

Consequently, Walvis Bay is a Ramsar site - a Wetland of International Importance – as well as one of 21 Important Bird Area (IBAs) (Simmons et al. 1998). Namibia acceded to the Ramsar Convention in 1995 and has registered 4 sites of International Importance: Walvis Bay; Sandwich Harbour; Etosha Pan and the Cuvelai Drainage; and the Orange River mouth (jointly with South Africa). The mission of the Ramsar Convention is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (http://www.ramsar.org/about/the-ramsar-convention-and-its-mission)

The importance of Walvis Bay as a destination for large numbers of migrant waders and resident species has been recognised since formal counts were undertaken in 1977 (Underhill & Whitelaw 1977). The bay holds substantial proportions of southern Africa's waders (i.e. Charadriidae waders, flamingos, and oystercatchers [Williams 1987, Simmons et al. 1998, Wearne and Underhill 2005]). Peak counts up to 150 000 birds (below) comprise 50% intra-African migrants, 45% Palearctic migrants and 5% residents (Noli-Peard and Williams 1991).

Migrant birds join the resident waders in August, to reach a peak in abundance from September to February in the austral summer, and start to move north in March to April (Hockey et al. 2005). Thus, Walvis Bay acts as a reservoir and destination for both Palearctic migrant waders (e.g. Curlew Sandpipers *Calidris ferruginea*, Red Knot *Calidris canutus,* Little Stint *Calidris minuta)* as well as intra-African migrants (e.g. Greater *Phoenicopterus ruber* and Lesser Flamingo *Phoenicopterus minor* and Chestnut-banded Plover *Charadrius pallidus*).

Counts have been undertaken for over 30 years at the wetland (Bridgeford 2013), and several papers and popular articles have highlighted the trends and compared them with adjacent wetlands. We sourced these and present the results here.

3.1 How does Walvis Bay rank in terms of waders relative to other southern African wetlands?

Walvis Bay and Sandwich Harbour occur as the top two wetlands in southern Africa in terms overall abundance of wading birds. The figures in Table 1 give the maximum numbers of birds at any one time for southern Africa's top 10 wetlands (in terms of avian abundance). They indicate that Walvis Bay has almost 10-fold as many birds at the maxima than any other wetland - other than Sandwich Harbour. These figures are swollen by massive numbers of Common and Black Terns at certain times numbering in the hundreds of thousands. A more accurate assessment, therefore, is the average numbers of waders over the entire period (Table 2).

Table 1. Top 10 coastal wetlands in southern Africa according to maximum counts of wading birds.

Wetland site	Maximum numbers (species richness) of waders	Reference
Walvis Bay Lagoon, Namibia	242,920 (51)	Wearne and Underhill (2005)
Sandwich Harbour, Namibia	401,806 (50)	Simmons et al. (2015)
Langebaan Lagoon, South Africa	38,901	Taylor *et al*. 1999
Swartkops River Estuary, South Africa	14,730	Taylor *et al*. 1999
Voëlvlei, Mossel Bay, South Africa	12,021	Taylor *et al*. 1999
Berg River Estuary, South Africa	11,614	Taylor *et al*. 1999
Baia dos Tigres, Angola	11,000 (25)	Simmons et al. 2006
Lake St Lucia, KZN	9,594	Taylor et al. 1999
Rietvlei, Cape Town	6,130	Taylor *et al*. 1999
Cunene River mouth Angola/Namibia	5,197	Anderson et al. 2001

The median number of wading birds found at Walvis Bay over a 30-year period was higher than at Sandwich Harbour (Table 2). This indicates that Walvis Bay - more consistently - holds larger numbers of birds than any other wetland in southern Africa. The numbers are highest in the austral summer when all the migrant waders congregate at the coastal wetlands. The winter numbers reflect, mainly, the resident species with a few over-wintering subadult migrants that do not head back to the northern hemisphere (Williams 1986).

Table 2. Median numbers of wading birds at Walvis Bay and Sandwich Harbour, summer and winter.

Wetland site	Median numbers of waders Summer : Winter	Number of counts and Reference
Walvis Bay Lagoon	155, 862 : 81, 854	N = 31, 31 (Wearne and Underhill 2005; Simmons et al. 2015)
Sandwich Harbour	96,146 : 52,386	N = 23, 24 (Simmons et al. 2015)

Red Data species and global proportions of each wader species

Biological value is not only measured in total numbers of species but also their significance in a global sense. For Ramsar qualification, a wetland must support 1% or more of the global flyway numbers of each species. Walvis Bay qualifies under these criteria for no less than 25 wetland species (Table 3) that reach or exceed 1% of the African flyway population in the terms of numbers on site (Wetlands International 2017).

Table 3. All wetland species in Walvis Bay that exceed the 1% population flyway threshold (Wetlands International 2017) for inclusion in the Ramsar criteria (after Wearne and Underhill 2005). Namibian Red Data species in red (Simmons et al. 2015).

Species	Maximum count (w= winter, s = summer)	1% threshold of flyway population	Palearctic Migrant (PM) Intra-African Migrant (I-AM) Resident (R)
Black-necked Grebe	13,129 (w)	150	I-AM
White Pelican	637 (s)	200	I-AM
White-breasted Cormorant	593 (w)	120	R
Cape Cormorant	10 850 (s)	2200	R
Greater Flamingo	43,679 (w)	750	I-AM
Lesser Flamingo	43,420 (w)	600	I-AM
Cape Teal	1,813 (s)	1,750	R
African Black Oystercatcher	184 (w)	55	R
Black-winged Stilt	768 (w)	230	I-AM
Pied Avocet	4,102 (w)	190	I-AM
Grey Plover	2,598 (s)	2,500	PM
Ringed Plover	4,545 (s)	1,900	PM
White-fronted Plover	3,108 (w)	180	R
Chestnut-banded Plover	8,428 (s)*	110	I-AM
Ruddy Turnstone	1,883 (s)	1,000	PM
Sanderling	15,169 (s)	1,200	PM
Little Stint	11,592 (s)	10,000	PM
Curlew Sandpiper	44,257 (s)	3,300	PM
Kelp Gull	5,053 (w)	700	R
Hartlaub's Gull	2,020 (s)	300	R
Black Tern	61,015 (s)	4,000	PM
Caspian Tern	116 (w)	15	I-AM
Swift Tern	811 (s)	200	I-AM
Sandwich Tern	1807 (s)	1,700	PM
Common Tern	93,617 (s)	6,400	PM
25 Species			**9 Palearctic migrants** **9 Intra-African migrants** **7 Residents**

* 47% of the world population

Red Data species

Of the 25 species that occur at Walvis Bay and exceed the 1% African fly-way population, 36% (9 of 25) species are threatened Red Data species (Table 3). Indeed, for one of these species, the Chestnut-banded Plover, the maximum numbers at Walvis Bay represent almost half (47%) of the world population (17 800) which includes the East African subspecies *C. p. venestus* (Simmons et al. 2007). For the southern African race (*C. p. pallidus*) alone the maximum Walvis Bay count represents 73% of the 11,500 birds estimated (Simmons et al. 2007).

Several other Red Data avian species also occur within the confines of Walvis Bay but in relatively small numbers. These include Damara Terns *Sterna balaenarum,* and Eurasian Curlew *Nemenius arquata.*

Long-term trends

To determine what influence any development has, in the short-term, on wetland bird numbers we need to understand the long-term population trends for all wader species. This has been undertaken for all main wader species over a 31-year period at Walvis Bay (Simmons et al. 2015) and the following trends were found:

- Significant **population declines** have occurred since the early 1990s in four of the 12 **long-distance migrants i**nvestigated (Turnstone, Ringed Plover, Red Knot, Little Stint);
- The most serious declines were for Little Stint and Ringed Plover, both with approximately 60–90% population declines;
- In contrast, **resident or short-distance migrant** wader populations all exhibited **stable or increasing** population levels relative to the early 1990s;
- Population levels increased for White-fronted Plover (*Charadrius marginatus*), Chestnut-banded Plover, Black-winged Stilt (*Himantopus himantopus*), Pied Avocet (*Recurvirostra avosetta*), and Greater Flamingo (*Phoenicopterus ruber*) relative to the early 1990s;
- The most abundant waders in these wetlands, Curlew Sandpiper and Sanderling (*Calidris alba*), had stable populations, although both populations may have had slightly higher levels from 2005 to 2006. Both species showed a marked drop in winter counts, especially in 2009 and 2010.

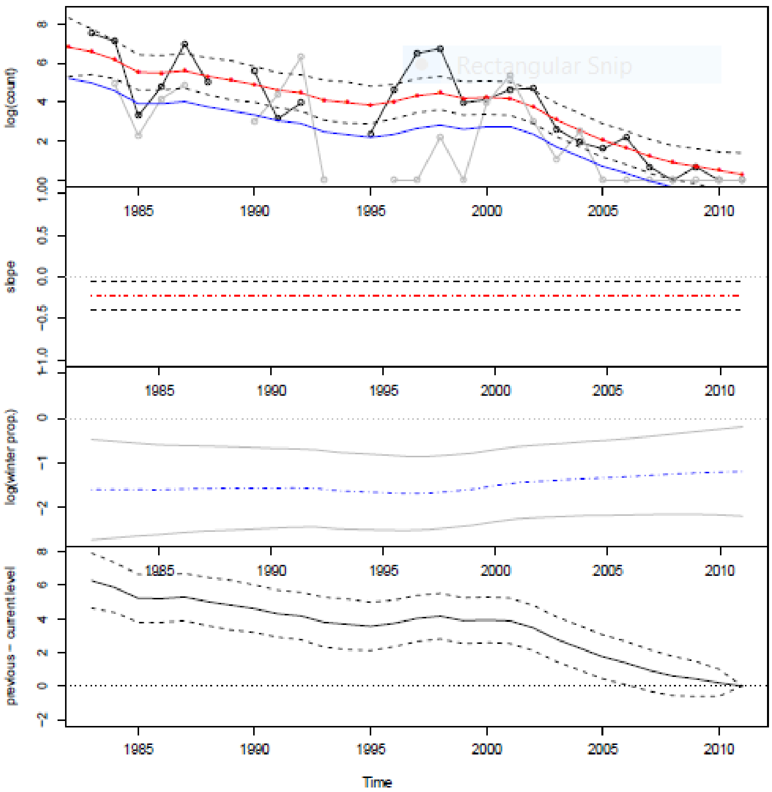


Figure 1: An example of long-term (31 year) population declines in long-distance migrants at Walvis Bay: **Red Knot.**

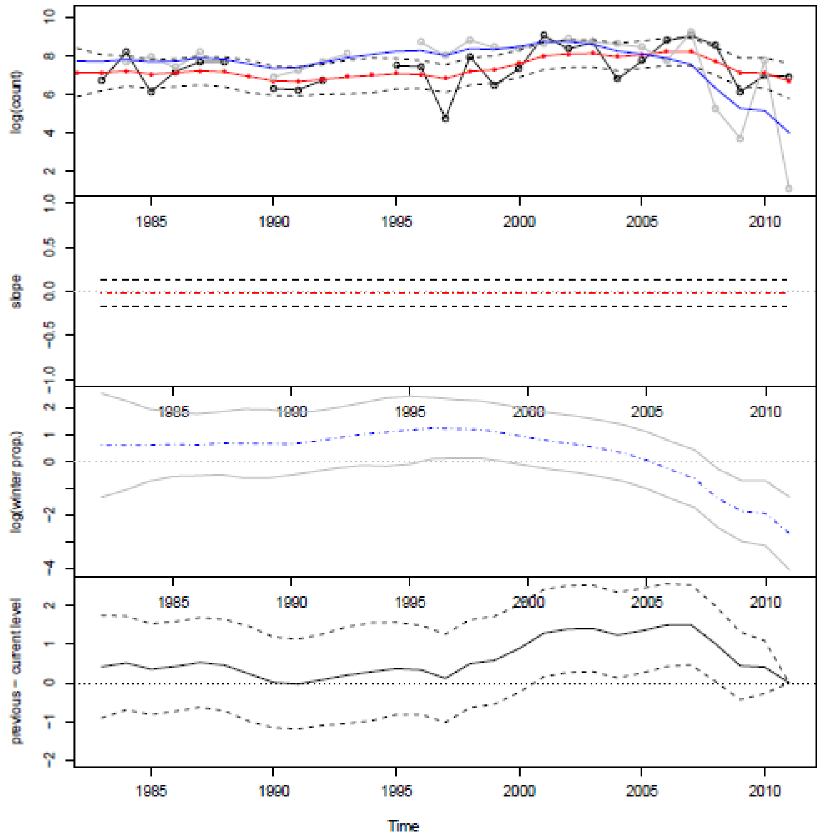


Figure 2: An example of long-term (31 year) population stability for a Red Data, short-distance migrant at Walvis Bay: **Chestnut-banded Plover**

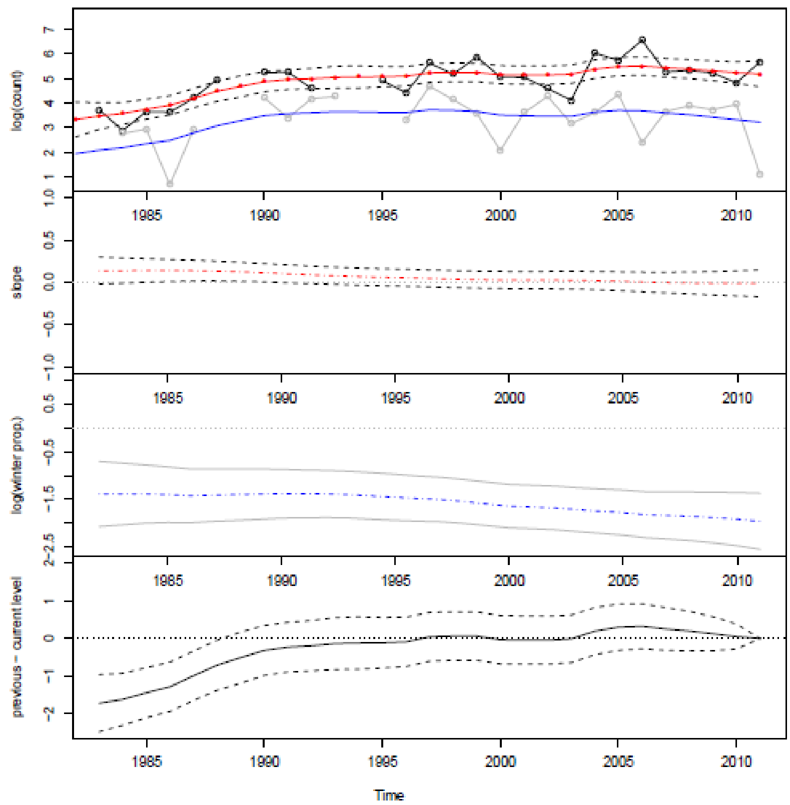


Figure 3: An example of long-term (31 year) population increase for a resident wader at Walvis Bay: **Common Greenshank**

Overall, despite the declines exhibited by some long-distance (Palearctic) migrants, and the stability or increases in resident species, we found no differences between Walvis Bay and Sandwich Harbour (Simmons et al, 2015). This suggests that Walvis Bay showed no adverse effects of the harbour facilities of the time or the potential dangers of pollution from bilge water, or oils. However, this is not true of the lagoon (below).

3.2 How important is the Lagoon: proportions and declines in birds using the lagoon?

Given that the most likely effects of the waterfront and marina will be on the birds of the lagoon, we need to determine what proportions, and which species, the lagoon supports of all Walvis Bay birds.

According to Williams (1997) the lagoon holds about 40% of the total number of waders found in the Walvis Bay wetland (Table 4). The maximum number of waders using the lagoon over this period was about 20 000. Given that the lagoon represents a biologically active area of 9 km^2 in a wetland (including salt works) of ~70km^2, the lagoon is approximately 13% of the total area (Figure 4). That it holds 40% of the waders indicates its high importance to the avian community in Walvis Bay.

For individual species, the proportion using the lagoon varied from 72% for Bar-tailed Godwits to 16% for Lesser Flamingos in the 1990s (Table 4).

Table 4: The maximum numbers (and proportions) of waders, terns and flamingos using the lagoon in the late 1990s (Williams 1997) vs 2013-2017 (this study).

Species (max all of Walvis Bay, 1997)	Proportion of birds in Lagoon (max counts) 1990s	2013-2017
Curlew Sandpiper (24 600)	9 600 (39%)	5 246 (decrease)
Little Stint (6 336)	2 406 (38%)	368 (decrease)
Sanderling (10 500)	4 100 (39%)	1 849 (decrease)
Chestnut-b Plover (6 953)	1 234 (18%)	3 027 (increase)
Grey Plover (3 440)	1 100 (32%)	775 (decrease)
Red Knot (1 850)	1 000 (54%)	3 (decrease)
Bar-tailed Godwit (903)	650 (72%)	888 (increase)
All waders (50 000)	**~20 000 (40%)**	**11 674 (42% decrease)**
Terns+Gulls		
Sandwich Tern (920)	397 (43%)	372 (decrease)
Common Tern (19 880)	5 963 (30%)	1 507 (decrease)
Damara Tern (392)	177 (45%)	79 (decrease)
Caspian Tern (129)	64 (50%)	58 (decrease)
Hartlaub's Gull (1145)	812 (71%)	324 (decrease)
Flamingos:		
Greater Flamingo (25 166)	13 003 (52%)	12 085 (decrease)
Lesser Flamingo (35 126)	5 759 (16%)	13 028 (increase)

We re-assessed the maximum numbers of waders using the lagoon (employing the same counting methods as Williams) from data provided by P Bridgeford, national coordinator for the Walvis Bay wetland count. We also took maximum count for each species and summed the maximums to derive the total number of birds. The data period from the last 4 years (February 2013 – February 2017) covered all winter (July) and summer (January) counts.

We found:

- Over the last 4 years the maximum number of waders using the lagoon was 11 674 (Table 4);
- That represents a decrease of ~42% in waders using the lagoon in the 20-year period from the mid-1990s to 2015 (mid-point of 2013-2017 counts);
- The 11 674-lagoon count represents just 12% of the present day maximum total of 100 835 waders recorded at Walvis Bay (Wearne and Underhill 2005);
- 11 of the 14-species recorded declined in maximum numbers in the lagoon;
- One species, the Red Knot, virtually disappeared from the lagoon (3 birds counted) having supported almost 1 000 birds 20 years before;
- One species of flamingo (Greater) declined and the other (Lesser) increased in their use of the lagoon (Table 4);
- Of the five Red Data species found in significant numbers in the lagoon, two species (Chestnut-banded Plover, Lesser Flamingo) showed increasing numbers, while three species exhibited declines;
- Two species that prefer saline saltpans (Chestnut-banded Plover and Lesser Flamingo : Turpie 2005, Simmons 2005) both increased in number in the lagoon, suggesting that conditions there are becoming more saline.

Thus, for the majority of comparisons, the species in the lagoon showed declining numbers; and overall abundance has dropped 42% in the 20 years since the mid-1990s (Table 4). Given that long-term trends (Simmons et al. 2015) show only four of the 12 long-distance migrants and none of the resident species have declined overall in the Walvis Bay wetland in the last 30 years, these declines in the lagoon cannot be explained by broad-scale declines. We, thus, conclude that it is the lagoon environment itself that is the cause of these avian declines.

Figure 4: The ~70 km^2 extent of the biologically active Walvis Bay wetland (red polygon) in relation to the lagoon (green polygon) of ~9km^2. The lagoon held about 40% of the waders at Walvis Bay in 1997, despite comprising just 13% of the entire wetland.

3.3 What is causing avian declines in the lagoon environment?

To determine what the reasons might be for the declines in the lagoon we asked: Are the declines associated with the port expansion? We suggest that the expansion of the container port might reduce the flow or amplitude of water into the lagoon and, thereby, increase sedimentation in the lagoon. More sediment may decrease feeding opportunities, decreasing the likelihood that wading birds will use the area. A prediction of this scenario is that a decline in bird numbers should be seen after the port expansion began construction in January 2015 (Google Earth images in Figure 5a and b).

Figure 5a: Google Earth images indicating Walvis Bay and lagoon prior to port expansion in August 2014 (left) and after expansion in January 2015 (right).

We found, as expected, a decrease in the average number of wetland birds using the lagoon immediately after port expansion (Figure 6). The average numbers dropped from 21 078 to 17 406 birds, a decline of 17% in 4 years. The long-term decline in wader numbers of ~42% over a 20-year period (1997 – 2017), reported above, gives an average rate of decline of approximately 2.1% per year.

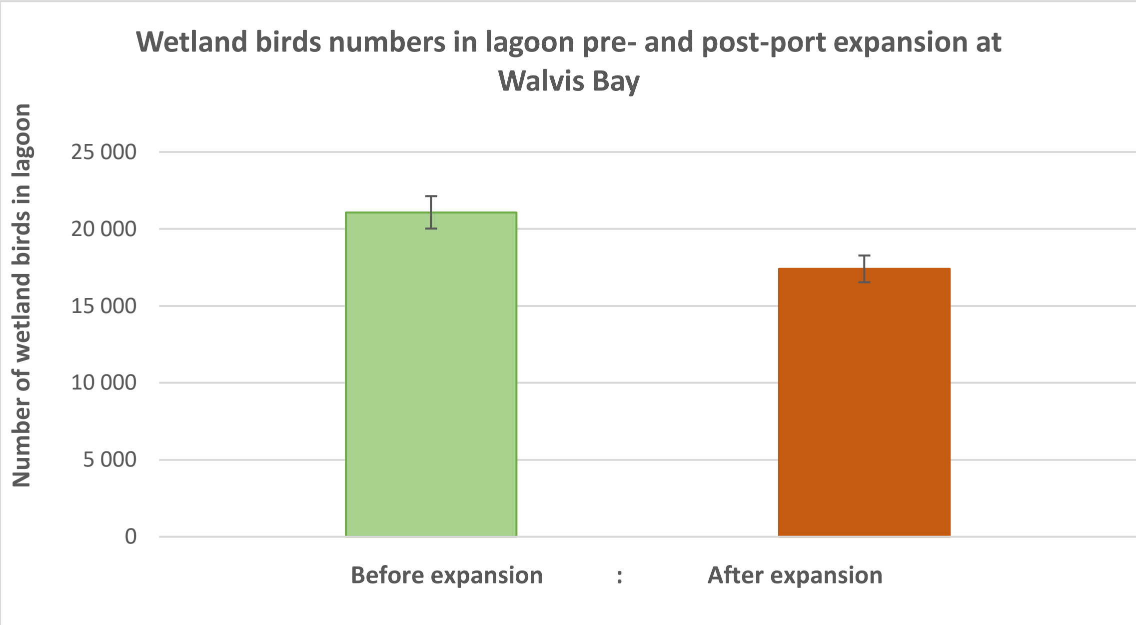


Figure 6: Average numbers of wetland birds recorded in the Walvis Bay lagoon 2 years before and 2 years after the port expansion (January 2015). Winter and summer counts from 2013-2014 (before) were compared to winter and summer counts from 2015-2016 (after).

Therefore, the decline in average numbers of 17% in 4 years before and after the port expansion is double that expected over the same time of (4y x 2.1% =) 8.4%.

This does not prove that the port expansion caused the decline of birds using the lagoon, but the fact that it is associated temporally with it, and doubled the rate of decline over a short period, strongly suggests the two are linked.

This suggests that any additional impacts (such as sedimentation, salinization, pollution or disturbance) caused by the construction of the Walvis Bay waterfront must be strictly minimised to reduce any additional impacts.

4 POTENTIAL IMPACT TO WALVIS BAY BIRDS FROM DEVELOPMENT

Key environmental issues

The main environmental impacts previously associated with developments in Walvis Bay include the following (summarised from Environmental Evaluation Unit [1999] and Namport Walvis Bay EIA study [2009]).

- **Environmental impact of the construction:**
  - Construction may include blasting, dredging,
  - noise of construction.

- **Environmental impact of prospective daily operational activities**
  - The waterfront shops and human activity,
  - Marina itself, noise, lights, pollution, increased water craft traffic.

- **Impacts of lights on the birds in the lagoon and alternatives;**
  - Bright lights are known to attract some night-flying birds and migrants,
  - Collisions with high-rise buildings or tall masts with bright lights.

- **Downstream impacts on avian food sources**
  - Sedimentation from dredging can smother avian foraging habitats,
  - Decreased water flow through lagoon can reduce tidal flushing,
  - Decreased tidal flushing will reduce the invertebrate fauna (Currie 1997),
  - Pollution (e.g. fish or engine oils) introduced to the lagoon (Currie 1997).

We have ranked these in terms of their potential impacts on the abundant birdlife in the lagoon in (Table 5). We have also provided mitigations.

Table 5: Key environmental issues, implications and mitigations arising from the development of the Walvis Bay waterfront and marina on the birds of the Ramsar site.

Potential impact	Reason for impact	Mitigation	Comment/significance
Construction phase: ➢ **Blasting causing disturbance to feeding or breeding birds** ➢ **Dredging operations** ➢ **Spillage of building materials, especially pollutants**	Sudden noise of **blasting** causes feeding birds to fly = reduced energy intake and relocate to less productive areas away from source of noise. **Dredging** operations release sediments and organic material that may smother habitats downstream on incoming tides, adding to the already sediment-rich and over-loaded southern sections of the lagoon. **Spillage** of construction materials including cement, oils and heavy metals	**Main construction** should avoid the main concentration of birds that occur chiefly in the summer months when the long-distance migrants are present. Dredging should avoid incoming tides which will add sediment down-stream into the lagoon, further smothering the feeding areas of the bird life. Strict guidelines to be followed for all waste products from the buildings	The best months for any blasting and dredging are in winter from May to August Out-going neap tides are best to avoid sediment. Research and monitoring of sediments must be ongoing and close down dredging activities if sediment loads are found to increase beyond acceptable levels. This is ranked as low-medium impact with low-medium significance with medium-term effects. With mitigation can be reduces to low/acceptable levels.
Environmental impact of prospective daily operational activities: ➢ **Waterfront and shops** ➢ **Marina traffic**	**Noise, lights and restaurant food** may act as a source of distraction/attraction to different species**.** **Increase watercraft traffic** in and out of marina may dissuade sensitive species of birds. Increased pollution such as bilge water and plastics are likely from the marina if motorised craft dominate the marina.	**Strictly control the entry and exit** of motorized craft (jet skis and motor boats) in the lagoon area. Only limited numbers of un-motorised craft should be allowed into the lagoon. Control elimination of waste, both human and industrial from the marina. Plastic and oil dumped or spilt in the marina will make it into the lagoon, adding to the environmental stress (high sediment, high salinity, high organic load) in the lagoon.	Likely to be low during daytime hours **Waste-disposal depots** could be created in the marina and marina "sheriffs" could ensure that all waste is disposed of responsibly. This is ranked as medium impact with medium significance with long-term effects. With mitigation can be reduced to acceptable levels.
Impacts of lights on the birds in the lagoon and alternatives ➢ collisions with high-rise buildings or tall masts with bright lights	**Tall masts or buildings with bright lights** attract and kill more birds in North America than any other anthropogenic source bar domestic cats (Loss et al 2014).	**Avoid high masts with constant lights. Avoid high buildings with lights on at night.** If lighting required by law, use flashing lights of colours other than white. Avoid the use of flood lights. Lights should be downward pointing, of lowest	This is ranked as medium impact with medium significance with long-term effects. With mitigation can be reduced to acceptable (low) levels.

➢ nocturnal migrants disorientated by bright lights	**Bright lights attract nocturnal species** and disorientate and kill migrant species that fly into the lights	illumination and be directed away from the lagoon. Flamingos migrate at night and increased use of the lagoon by Lesser Flamingos may mean greater likelihood of disorientated birds. Thus, flood lights and lights on tall buildings should be avoided entirely.	
Downstream impacts on avian food sources: ➢ Sedimentation ➢ Decreased tidal flushing ➢ Decreased invertebrate fauna, ➢ Increased salinity (Currie 1997) ➢ Pollution (e.g. fish or engine oils) introduced to the lagoon (Currie 1997)	**Sedimentation** from dredging can smother avian foraging habitats in the lagoon forcing birds to move elsewhere **Decreased tidal flushing** will decrease invertebrate fauna and may lead to biological "dead zones" un-used by birds or fish. Decreased flushing and increased sedimentation appears to have led to an accelerated decrease in bird numbers: (i) 17% decrease in bird numbers since the port expansion in January 2015 (ii) increased salinity as evidenced by increasing numbers of two saline-loving species (Chestnut-banded Plover and Lesser Flamingo). **Pollution from fish oils, or industrial** contaminants can kill invertebrates and birds directly, and this can threaten the two Red Data species that are increasingly using the more saline conditions of the lagoon	**The marina should not impede the flow** of water in the main channel in any way. **The lagoon-side wall protecting the marina** should be constructed on the north-side of the Raft restaurant, parallel with the coastline. Ideally it should not restrain the flow of water in any way. This is best undertaken with pilings supporting the wall, and no solid construction (i.e. not filled). This could also be achieved by a bridge opening at the south-eastern end allowing the water to flow through and on towards the lagoon. A wall that does not project out into the main lagoon channel at all is the preferred option to decrease the impact of the marina on further sedimentation and reduction of tidal flushing. Long-term the lagoon is likely to silt up and become too saline for most species to feed. Thus, remedial action is required now as the port expansion and the waterfront/marina are developed.	Sedimentation is obvious from the Raft restaurant from Google images and this in combination with the port expansion appears to already be reducing bird numbers. So, this is a high priority to get right. This is ranked as high impact with high significance with long-term effects. With mitigation, this can be reduced to medium levels, that will require research to determine the long term effects. Remedial action may be required to avoid the long-term sedimentation, increased salinization and dying of this biologically and internationally renowned wetland.

		Dredging new channels into the lagoon to increase tidal flushing may be required for the long-term sustainability of the ecosystem. **Pollution control and cleaning** and emptying of bilge water, oils and rubbish needs strict control.	

5 CONCLUSIONS

From previous surveys and research, it is obvious that Walvis Bay is a thriving destination and feeding hub for thousands of long-distance migrant birds from as far as Russia and Eurasia. However, the lagoon, which 20 years ago was, area-for-area, the most productive single element of the Ramsar wetland (supporting 40% of the wader population in 13% of the area) is now ecologically compromised. The lagoon currently only supports 12% of the migrant wader population, and 11 of the 14 species using it have declined in the last 20 years.

That this is probably the result of ongoing anthropogenic activities around the lagoon is evidenced by the accelerated (17%) decrease in birds using the lagoon immediately after the port expansion was started in January 2015.

Surveys of the lagoon and its rate of sedimentation indicate that most of the sediments are wind-borne from the dune fields to the east (Ward 1997, Engelhard and Sell 2013). Aeolian sedimentation from other directions seems to be reduced (captured) by the presence of the salt works to the west and south-west of the lagoon and Walvis Bay town, and the bay to the north. According to Engelhard and Sell 2013) the flooded pans to the east of the lagoon capture sediment blown in from the east (particularly with berg winds). As a result, the pans have reduced in size from 190 ha to 50 ha over a 12 year period (2001 to 2013). Once filled, more sand will penetrate the lagoon. At the same time sedimentation and a layer of 20-50 cm of “oil-like black substance” was found in the southern end of the lagoon (Engelhard and Sell 2013). According to the authors they believe this to be sediments and organic matter brought in from the bay on the high tide, but not taken out by the ebb tide. While it was not stated in their report, this suggests a low-oxygen anaerobic matter and this may correspond to the biologically “dead zones” reported in the surveys UNam report (Unam 2013).

We therefore, concur with the conclusion of Currie (1997, p8) who stated that “*the most critical factor regarding the biota is to maintain tidal flux: the lagoon must provide the physical basis to support its biota”*

Previously the CSIR and Unam (Tjipute and Skuuluka 2006) reported that “*the upper [southern] reaches of the lagoon support insignificant populations of benthic fauna. The surface sediments were anoxic consisting of a silty mud with a high content of organic material. The strong southerly winds reduce the tidal penetration, particularly at neap tides, resulting in elevated temperatures and high salinities which may exceed the tolerance limits of the benthic species occurring in the lagoon*” (Namport 2010).

Currie (1997) reported that the invertebrate animals are distributed into zones according to distance from the mouth. The middle subtidal reaches of the lagoon support the greatest species diversity and density including bivalves and tube worms.

According to Namport (2010) the origin of the organic material transported into the lagoon from the bay seem to partly originate from waste or spill from the fish factories in the harbour. Therefore, waste from the harbour and fish industry should be highly regulated and reduced, to avoid creating more biologically dead zones at the southern end of the lagoon.

Each of these suggest that high organic loads, high salinity and low tidal flushing at the southern end of the lagoon are leading to areas of lower biological activity and "*insignificant populations of benthic fauna*" (Currie 1997).

Further sedimentation or deposition of organic material in these areas will result in reduced proportions of wading birds and will, probably, result in the long-term death of the lagoon that once supported 40% of the migrant waders (Williams 1997).

Further developments therefore, that impede the flow of water into the lagoon, reducing the tidal flushing and increasing salinity and increase pollutants, should be avoided.

The waterfront and marina, thus, present significant challenges to the developers to mitigate any effects of reduced tidal flow or amplitude and to avoid strong lighting, and particularly pollutants such as oil, human waste, plastics and chemicals that may enter the lagoon. All of these may continue to accelerate the present decline seen in wetland bird numbers using the lagoon.

Acknowledgements

Particular thanks are due to Peter Bridgeford for providing up-to-date counts for the Walvis Bay lagoon from 2013-2017, and Jessica Mooney of ECC for supplying background data.

6 REFERENCES

Anderson M.D., Anderson, R.A., Anderson, S.L., Anderson, T.A., Bader, U., Heinrich, D., Hofmeyr, J.H., Kolberg, C., Kolberg, H.,Komen, J., Paterson, B., Paterson, J., Sinclair, K., Sinclair, W., van Zijl, D. & van Zijl, H. 2001. Notes on the birds and other animals recorded at the Cunene River mouth from 6–8 January 2001. *Bird Numbers* 10(1): 52–56.

Barnard PE (ed). 1998. Biological Diversity in Namibia: a country study. Ministry of Environment and Tourism.

Breen C 1991. Are intermittently flooded wetlands of arid environments important conservation sites? Madoqua 17: 61-65.

Bridgeford P. 2013. Thirty years and still counting: The history of bird counts in Walvis Bay *Namibian Scientific Society Mitteilungen/Newsletter* 54: 5 – 12.

Currie B. 1997. Invertebrate fauna in the Walvis Bay lagoon. In: *Towards an integrated management and development plan for the Walvis Bay Lagoon and environs*. Unpubl. report of the Environmental Action Committee, Walvis Bay.

Environmental Evaluation Unit . 1999. Assessment report of the Walvis Bay naval base. UCT, Cape Town.

Hockey, P.A.R, Bosman, A.L. 1983. Conservation management of the Walvis Bay Lagoon with special reference to its importance as a bird habitat. Unpubl. report, Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Cape Town.

Sakko, A.L. 1998. Biodiversity of marine habitats. In: Barnard, P. (ed.) *Biological diversity in Namibia: a country study*. Windhoek: Namibian National Biodiversity Taskforce, Directorate of Environmental Affairs: 189–226.

Engelhard D, Sell WA. 2013. Report on the "siltation survey of the Walvis Bay lagoon" Tender notice 105/2012 For the municipality of Walvis Bay. African Geomatics, Windhoek, Namibia.

Martín B, **Delgado S, de la Cruz A, Tirado S,** Ferrer M. 2015. Effects of human presence on the long-term trends of migrant and resident waders: evidence of local population declines. Animal Conservation 18: 73–81.

Molloy F. Reinikainen, T. (eds) 2003. *Namibia's marine environment.* Windhoek: Directorate of Environmental Affairs.

***NAMPORT Container Terminal Expansion EIA** 2009.* Unpublished EIA report.

Noli-Peard KR, Williams AJ. 1991. Wetlands of the Namib Coast. Madoqua 17: 147-153.

Simmons RE, Kolberg H, Braby R, Erni B. 2015. Declines in migrant shorebird populations from a winter-quarter perspective. *Conservation Biology* 29: 877-887.

Simmons RE, Brown CJ, Kemper J. 2015. Birds to watch in Namibia: red, rare and endemic species. Ministry of Environment & Tourism, Namibia Nature Foundation. Windhoek, Namibia.

Simmons RE, Baker N, Braby R, et al**.** 2007. The Chestnut-banded Plover is an overlooked globally Near Threatened Species *Bird Conservation International* 17:283-293.

Simmons RE. 2005. Lesser Flamingo In: Hockey PAR, Dean WRJ, Ryan PG. Roberts birds of Southern Africa. John Voelcker Bird Book Fund, Cape Town.

Simmons RE, Sakko A, Paterson J, Nzuzi A. 2006. Birds and conservation significance of the Namib Desert's least known coastal wetlands: Baia and Ilha dos Tigres, Angola. *African Journal of Marine Science* 28: 713–717.

Simmons, R.E. 1997. Ecological factors promoting large bird populations at Walvis Bay. In: *Towards an integrated management and development plan for the Walvis Bay Lagoon and environs*. Unpubl. report of the Environmental Action Committee, Walvis Bay.

Taylor B. 1999. **Taylor, P.B., Navarro, R.A., Wren-Sargent, M., Harrison, J.A. Kieswetter, S.L.** 1999. *TOTAL CWAC Report: Coordinated Waterbird Counts in South Africa, 1992–97*. Cape Town: Avian Demography Unit, University of Cape Town.

Turpie J. 2005. Chestnut-banded Plover In: Hockey PAR, Dean WRJ, Ryan PG. Roberts birds of Southern Africa. John Voelcker Bird Book Fund, Cape Town.

Underhill, L.G. & Whitelaw, D.A. 1977. An ornithological expedition to the Namib coast. Cape Town: *Western Cape Wader Study Group*.

Ward, J.D. 1997. Sedimentation of the Walvis Bay Lagoon. In: *Towards an integrated management and development plan for the Walvis Bay Lagoon and environs*. of the Environmental Action Committee, Walvis Bay.

Wearne K, Underhill LG. 2005. Walvis Bay, Namibia: a key wetland for waders and other coastal birds in southern Africa. *Wader Study Group Bull.* 107: 24–30.

Wetlands International. 2017. Waterbird population estimates. Wetlands International, Wageningen, The Netherlands. Available from wpe.wetlands.org

Williams, A.J. 1987. Conservation management of the Walvis Bay wetland with particular reference to coastal bird numbers and their conservation significance. Unpubl. *Report to Walvis Bay Round Table, Walvis Bay.*

Williams AJ. 1997. Birds of the Walvis Bay laooon and the associated wetlands, including the bird sanctuary. In: *Towards and integrated Management and Development plan for the Walvis Bay Lagoon and environs.* Unpubl. report Walvis Bay Environmental Action Committee.

APPENDIX 1: Raw data for lagoon-side birds 2013-2016. Red Data species in **red** (data as per Peter Bridgeford)

WALVIS BAY BIRDS	Jul-16	Jan-16	Jul-15	Feb-15	Jul-14	Feb-14	Jul-13	Feb-13
	74 772	***95 280***	***56 448***	***148 475***	***95 386***	***109 044***	***103 106***	***118 850***
		40						
	LAGOON ONLY							
Avocet	407	69	367	2	**589**	9	227	441
Coot Red-knobbed					**1**			
Cormorant Bank								
Cormorant Cape	155	269	57	1	79	331	248	**346**
Cormorant Crowned					1			
Cormorant White-breasted	26	10	23	8	3	10	**37**	10
Curlew		**2**						
Egret Cattle	**10**				8		7	
Egret Little	2	7		2	11	13	9	**18**
Flamingo Greater	10240	4512	9209	5603	5189	4184	**12085**	6847
Flamingo Lesser	**13028**	1946	2017	295	2096	1546	8024	
Flamingo Unidentified					5200			
Godwit Bar-tailed		1133		106	2	**888**	62	215
Godwit Black-tailed								
Goose Egyptian					1			
Grebe Black-necked					3		5	**8**
Grebe Little								
Grebe Great-crested								
Greenshank	8	53	16	2	15	28	15	**80**
Gull Grey-headed						1	**3**	2
Gull Hartlaub's	183	114	122	268	126	**324**	133	226
Gull Kelp	307	172	760	268	98	258	493	**816**
Heron Grey	14	19	46	17	5	19	21	**62**
Knot Red								**3**
Oystercatcher African Black		34	3	21	8	8	7	**36**
Pelican White	267	86	62	277	188	**445**	102	217
Plover Blacksmith	20		11		13		**32**	
Plover Caspian								
Plover Chestnut-banded	48	32	**3027**	944	1411	608	400	1466
Plover Common Ringed		50	2	6		**20**		2
Plover Golden			1					
Plover Grey	4	74	156	**775**	8	507	53	681
Plover Kittlitz's		6						
Plover Mongolian								
Plover Ringed								
Plover Sand								
Plover Three-banded			5		2		**7**	1
Plover White-fronted	54	98	176	38	**1435**	94	132	404
Ruff		1	7	1		20		**21**
Sanderling		1466		**1849**	10	377	6	210
Sandpiper Broadbilled								
Sandpiper Common					2			**4**
Sandpiper Curlew	6	125	99	1228	842	1512	166	**5246**

Sandpiper Marsh								
Sandpiper Terek								
Shoveler Cape			**14**					
Stilt Black-winged	5	2	28		3		8	**34**
Stint Little		4	1	9	5	**368**	33	138
Teal Cape	46		100	14	25		27	**212**
Tern Black						**65**		
Tern Caspian	53	36	27	25	11		46	**58**
Tern Common	8	**1507**		117	30	735	5	122
Tern Damara		2		60				**79**
Tern Sandwich		33		1	1			**372**
Tern Swift	41	46	25	8	22	4	25	**295**
Tern Unidentified	200	200		524		230		**2862**
Turnstone	30	142	2	21	27	155	11	**525**
Unidentified large waders			2	10				
Unidentified medium waders		**300**					190	
Unidentified small waders	98	290	951	1652	850	3054	457	**5000**
Whimbrel	3	24	7	22	5	11	11	**16**
Totals	**25 263**	**12 864**	**17 323**	**14 174**	**18 325**	**15 824**	**23 087**	**27 075**
	winter	summer	winter	summer	**winter**	**summer**	**winter**	**summer**
	After naval base				**Before naval base**			

Ave for last 4 years 19 242

Max wader counts **(bold)** over last 4 years **11 674**