# Floating Roosts

## Keeping threatened shorebirds afloat

In a world with increasing coastal development, storm surges and rising sea levels, a habitat crisis has emerged for migratory shorebirds. This project led by BirdLife Australia and a flock of international partners seeks to provide emergency high-tide resting areas for shorebirds in altered coastlines, not by turning our backs on the tide, but by rising above it.

birdlife
AUSTRALIA

## Birdlife's commitment to shorebird conservation

BirdLife Australia is proud to be the nation's largest bird conservation organisation. As an independent, not-for-profit organisation, our aim is clear: to create a bright future for Australia's birds.

We have been a voice for Australia's birdlife for well over a century, protecting birds and their habitats through our robust programs and informed advocacy. It is the powerful passion of our members and supporters which keeps us moving forward and gives us our strength. With active branches and groups across the country, we are able to tap into local issues as well as understanding the bigger picture.

BirdLife Australia's Migratory Shorebirds Program aims at improving the protection of our shorebirds. BirdLife Australia's Conservation Action Plan (CAP) for Migratory Shorebirds brings together national and Flyway-wide partners including federal, state and local governments, universities, NGOs and volunteer groups to coordinate and implement a Flyway-wide response to the extinction crisis.

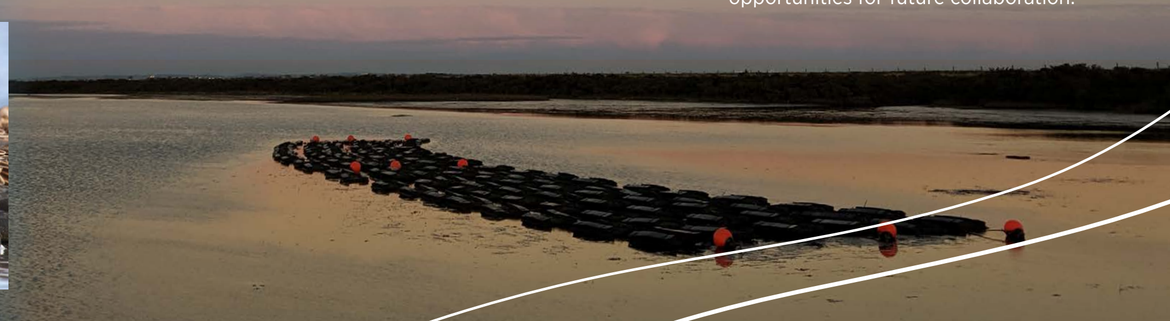
BirdLife Australia's Broome Bird Observatory and Australasian Wader Studies Group are key partners in the delivery of the program.

# The floating roost trial

Appropriate high tide roosts (resting areas) are necessary to help migratory shorebirds maintain a positive energy balance while making journeys of over 10,000km to and from breeding grounds. However, many roosting areas the Yellow Sea coast these areas are the first to be affected by development and disturbance.

Our surveys of one critical staging area identified that most natural roosts were available on fewer than half of all high tides. During these periods it is estimated that over ten thousand birds may be without appropriate local roosting opportunities. Unfortunately this is not an isolated case and where options for traditional roost restoration or creation are not achievable we have to innovate. BirdLife Australia looked to an unlikely partner, the oyster farmers of Australia. Floating oyster farm infrastructure is utilised by shorebirds on the east coast of Australia. The Floating Roost Trial seeks to adapt and optimise this concept to be used as last resort roost sites in highly modified coastlines.

This brochure details Phase 1 of the Floating Roost Trial: project rational, implementation, results, opportunities and limitations. It also looks forward to Phase 2 and identifies opportunities for future collaboration.



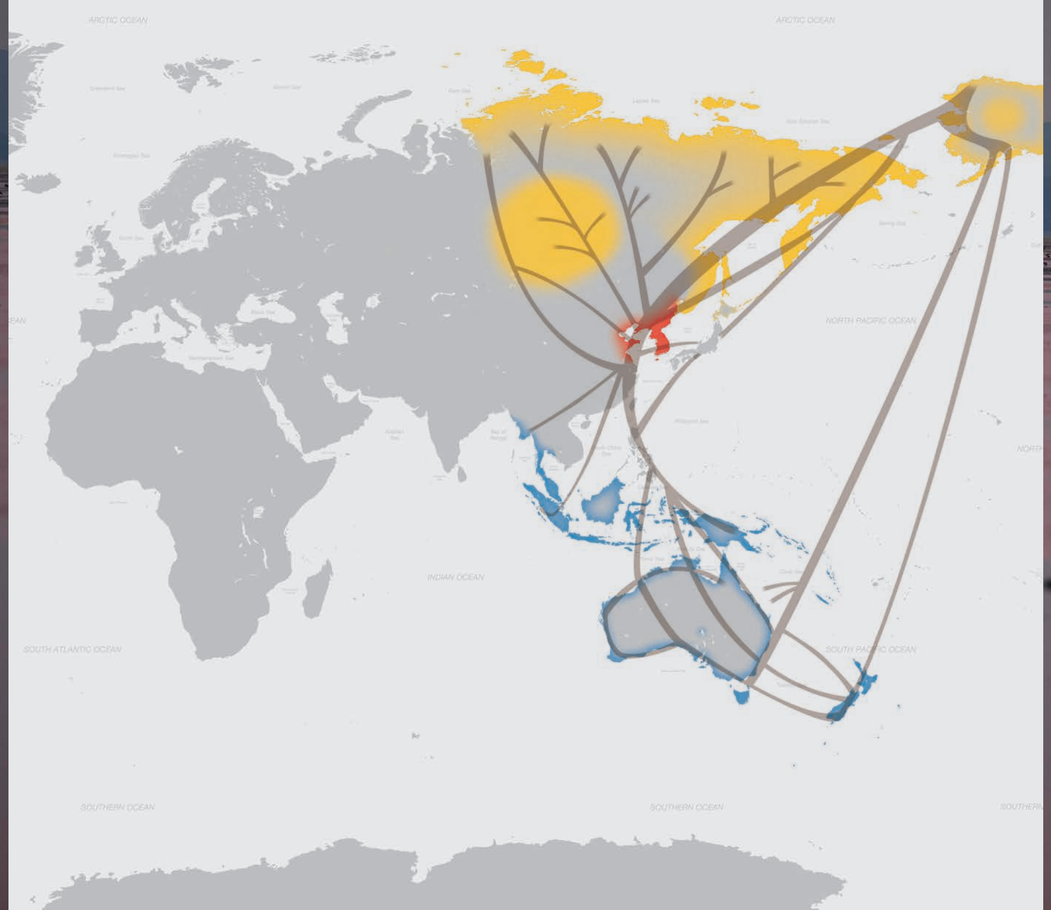
# Migratory Shorebirds:
## wanderers between hemisphere

Migratory shorebirds that use the East Asian-Australasian Flyway traverse the globe on annual migration to and from arctic breeding grounds, encountering a wide variety of landscapes spanning many administrative boundaries and potential threats.

Thirty-six of these species spend their non-breeding period in the wetlands of Australia. Birds that embark on migration, stop over in an increasingly limited number of significant coastal wetlands in the Yellow Sea to rest and refuel.

Over the last three decades an overall trend of decline has been detected in shorebird populations throughout the Flyway. Largely driven by habitat loss and altered hydrology, the most significant trends have been evident in populations heavily dependent on the Yellow Sea, with some species declining at a rate of 8% a year.

As joint custodians of these populations, the Australian Government, international NGOs, academic institutions and now the private sector are increasingly collaborating with Yellow Sea stakeholders to stem the rate of habitat loss and degradation that has driven shorebird declines.



# Roosting shorebirds

## What is a good roost and why does it matter?

In coastal environments, roosting (resting) occurs around most high tides. As the tide rises, widely dispersed, feeding birds become increasingly concentrated as tidal flats become inundated. At high tide, when no feeding habitat remains, many thousands of birds may be squeezed into a small “roost site” awaiting the tide to recede. While at roost, birds focus on preserving energy, or running routine maintenance on important flight feathers. In order to minimise energy expenditure and avoid predation, shorebirds have a few requirements for an ideal roosting site.

| CONDITION | BENEFIT |
|---|---|
| Close to feeding areas | Minimise energy spent in travel |
| In shallow water or on wet sand | Reduce overheating |
| Sheltered from the elements | Reduce heat loss |
| Isolation (islands, sand spits etc) | Reduce predation and disturbance |
| Free of tall structures including vegetation | Enable surveillance for potential predators |

Table 1: Characteristics of an attractive shorebird roost

When selecting a roost, trade-offs between the importance of these factors may vary depending on: tide, weather conditions, species of shorebird or temporary disturbances within the site network. They may even vary from day to night.

## What is the problem?

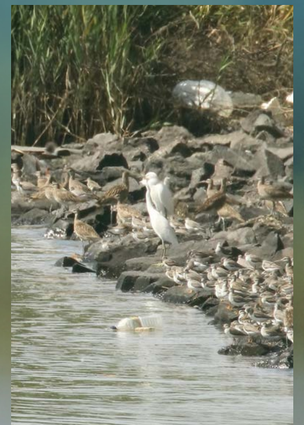
In the absence of an appropriate high tide roost, birds may have to settle for sub-optimal sites or fly some distance from their feeding ground to find a site. In the very worst scenarios birds may be forced to the sky in swirling flocks awaiting the tide to recede and revealing somewhere safe to land. Like planes in a holding pattern they burn precious fuel in a behaviour known as aerial roosting.

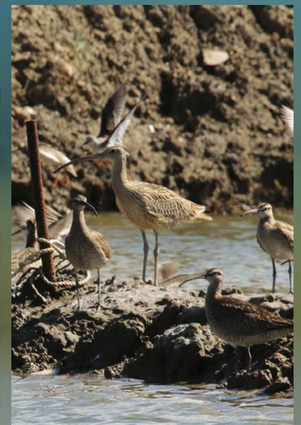
In each of these cases a bird may be forced to make a choice which burns precious energy that they should be storing for their onward migration.

High tides at Sol Ri on the Soecheon Getbol (ROK) meet hard walls rather than beaches.

Birds are forced to roost on dredge spoil pipes in the Geum Estuary (top), sea walls (bottom left ) or on the levees of small shrimp ponds (bottom right).

Surveys of the Republic of Korea’s most significant shorebird habitat, the Seocheon Getbol, identified that the suitability of high-tide roosts in the region is likely to be a major limiting factor to staging shorebirds maintaining a positive energy balance. The energy deficit incurred may have population-level impacts if birds are not capable of completing migration or successfully breeding upon arrival.





## Conventional approaches and a new concept

In understanding the necessity to maintain supratidal* roost sites - in the context of climate change induced sea-level rise and broad scale habitat loss - the conservation and maintenance of existing natural and artificial habitats should be prioritised. In cases where this is not possible (e.g., highly developed areas or those subject to high levels of disturbance), new, artificial roosts will be necessary.

To date, the construction of artificial roosts for shorebirds has involved significant earthworks and hydrological alteration to create permanent, static structures (islands, banks and groynes). These interventions are successful in creating suitable shorebird habitat but may:

- come at significant cost to land managers
- have undesired effects on surrounding habitats
- be subject to rapid degradation (e.g. erosion or colonisation by coastal vegetation).

So what if rather than building on intertidal habitats we sought to rise above it?

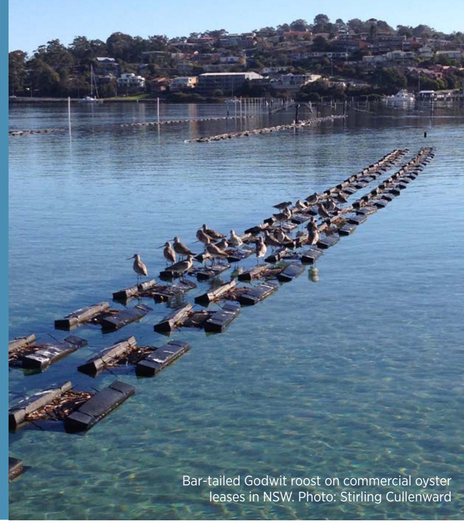
*beyond the reach of the tide

Red-necked Stints and Curlew Sandpiper roost on floating eel grass wrack on spring tides at a beach in South Australia

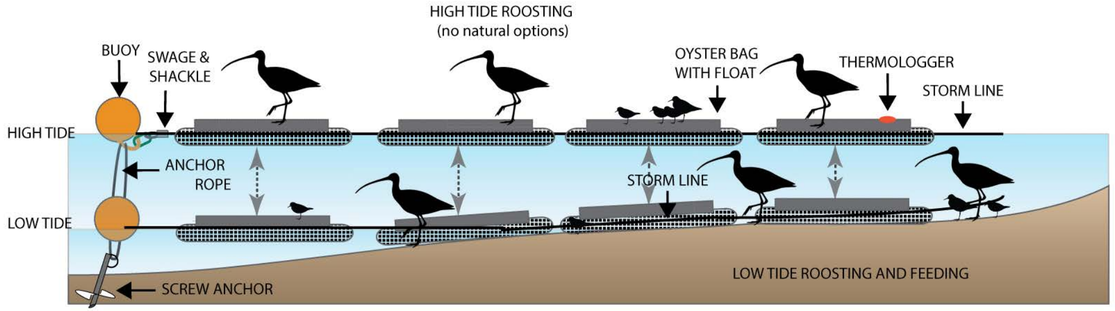
## A new approach to artificial roosts: Let me float this by you

To address the issue, BirdLife Australia looked to an unlikely partner, the oyster farmers of Australia. Floating oyster farm infrastructure is utilised by shorebirds in the east coast of Australia. The project initiated the Floating Roost Trial by optimising commercially available materials as roost sites in highly modified coastlines.

Floating roost sites, whether natural or artificial, may form preferential high-tide roost sites for a number of reasons. They are generally consistent throughout the tide cycle and immune to climate change induced sea-level rise. In addition, they are resistant to terrestrial predators and vegetation colonisation and can be relocated on, or adjacent to tidal feeding areas.



Bar-tailed Godwit roost on commercial oyster leases in NSW. Photo: Stirling Cullenward



# Threatened shorebirds profile

## Far Eastern Curlew

One of the East Asian Australasian Flyway's most iconic and striking migratory shorebirds is also one of it's most threatened. The Far Eastern Curlew is the largest migratory shorebird in the world. Its characteristically long bill is used to probe the mud and dislodge crabs from the safety of their burrows.

Sadly, the Curlew's decline over the past decades has seen the population decrease by more than 85%, resulting in a national listing of Critically Endangered. This staggering trend has been linked to the Curlew's high reliance on the Yellow Sea as a staging site. With over 95% of the population relying on the region each year, large scale habitat loss has taken its toll.

The Far Eastern Curlew occurs only in our Flyway, and about 75% of the world's curlews winter in Australia. Spending up to 6 months on our shores, we have a particular responsibility to protect them and the smaller shorebirds that live in their shadow.

## Curlew Facts

**Body mass**: up to 1.3 kg

**Population**: 35,000

**Trend**: Very severe decline (>80%)

**Breeding**: Arctic

**Average male bill length**: 15cm

**Average female bill length** 18.5cm

Max bill length: 20cm.

Far Eastern Curlew. Photo:Dan Weller

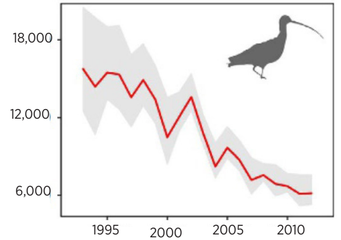
## Distance, disturbance & predation

The key threatening processes faced by Far Eastern Curlews (and many other migrants) in Australia are:

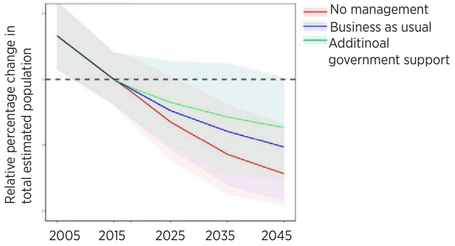
1. coastal development
2. disturbance
3. coastal degradation
4. sea level rise

The species is particularly dependent on undisturbed roosting sites; they are more sensitive than other shorebirds and will take to the wing much sooner. Plans to mitigate any one of the above threats at any one site need to be cognisant of the interplay between other ongoing and predicted threats.

The multiplying and accumulating threats to Curlews on our coastlines require urgent action. Where traditional interventions have been exhausted new ideas are needed to support the Curlew. Even with strong conservation management interventions, Australia's Threatened Species Strategy Review (2019) has predicted that the population will continue to decline.




Total abundance of Eastern Curlew between 1993 and 2012. Estimates are posterior means from Bayesian N-mixture models of counts across Australia and New Zealand, including the majority of internationally important sites. Grey shading denoting the 95% CRI (Studds et al 2017)




The estimated population trajectory for Eastern Curlew derived from expert elecitation based on three degrees of management scenarios (Geyle et al 2019)

# Living with Far Eastern Curlew in a land girt by sea

To prioritise Curlew sites which would provide the greatest benefit from targeted conservation management (including the potential for temporary deployment of floating roosts) the following may be considered:

- How significant is the role that site nationally and internationally?
- Are there ongoing threats to Curlews?
- Have interventions been attempted?
- What would be the likelihood of success of any one intervention in the short and long term?

| Shorebird area | State | Max Count |
|---|---|---|
| Moreton Bay | QLD | 2,304 |
| Westernport | VIC | 1,432 |
| Shoalwater | QLD | 1,020 |
| Great Sandy Strait | QLD | 988 |
| Port Stephens | NSW | 944 |
| Eighty Mile Beach | WA | 886 |
| Corner Inlet | VIC | 830 |
| Roebuck Bay | WA | 706 |
| Pumicestone Passage | QLD | 663 |
| Central Queensland Narrows | QLD | 600 |
| Broadsound | QLD | 599 |

Far Eastern Curlews subjected to disturbance. Gold Coast Broadwater, Moreton Bay Marine Park, QLD. Photo: Todd Burrows

# Key Far Eastern Curlew site examples

Below are three examples of internationally significant Eastern Curlew sites where roosting habitats face varying threats and management challenges.

## MORETON BAY, BRISBANE

- #1 Eastern Curlew site in Australia
- Supports 35,000 shorebirds each summer
- Nine species in internationally significant numbers
- 15 of 218 mapped roosts have become unsuitable.
- 1/3 of all shorebirds now roost in artificial habitats (Fuller et al 2021)

**Ongoing threats to roosts:**

- Disturbance (beach users and watercraft)
- habitat loss

Above; Raby Bay Estate
Photo: Nick D

## ROEBUCK BAY, BROOME

- Part of Australia's #1 shorebird site
- Supports 120,000 shorebirds each summer.
- 21 species in internationally significant numbers
- Two major spring tide roosts: the northern beaches and Bush Point

**Ongoing threats to roosts:**

- Disturbance
- High rates of disturbance at critical spring tide roosts on the northern beaches, exacerbated in dry season.

Above; Public access to Simpson Beach
Photo: Nick D

## CORNER INLET, GIPPSLAND

- Part of Victoria's #1 shorebird site
- 29,000 shorebirds
- Six species in internationally significant numbers

**Ongoing threats to roosts:**

- Disturbance
- Invasive vegetation (spartina)
- Native vegetation expansion (mangrove)

Above; Bar-tailed Godwits roosting in deep water among encroaching mangroves at Toora Point
Photo: Clare Morton

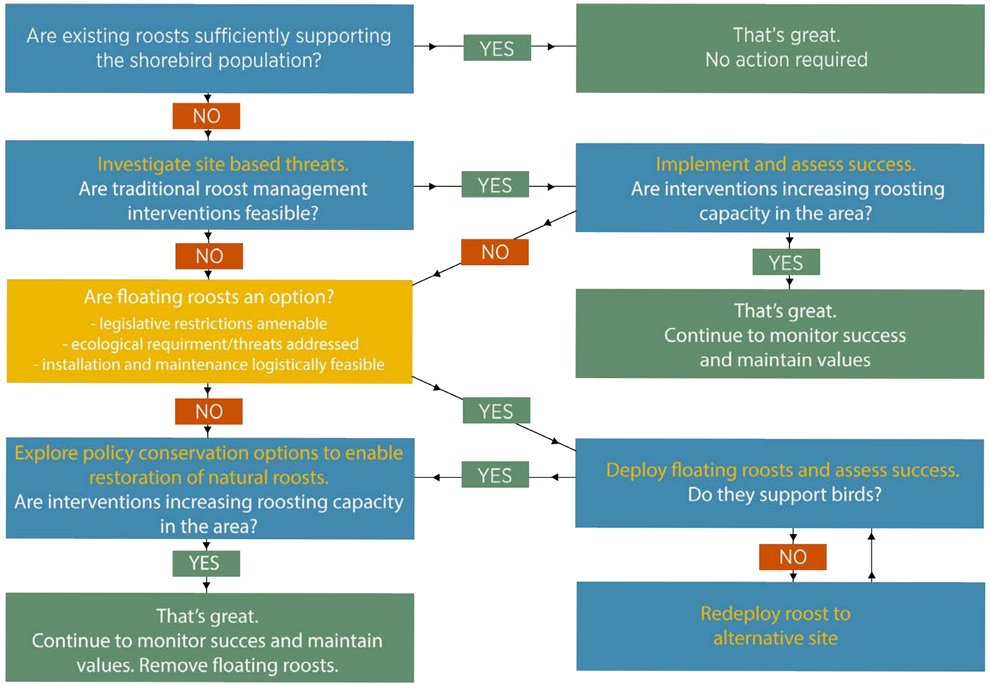
# Are floating roosts an option?

The floating roost decision tree (right) has been developed to provide conservation managers with a guide to population management considerations that need to be discussed when assessing the necessity for additional artificial roosts.

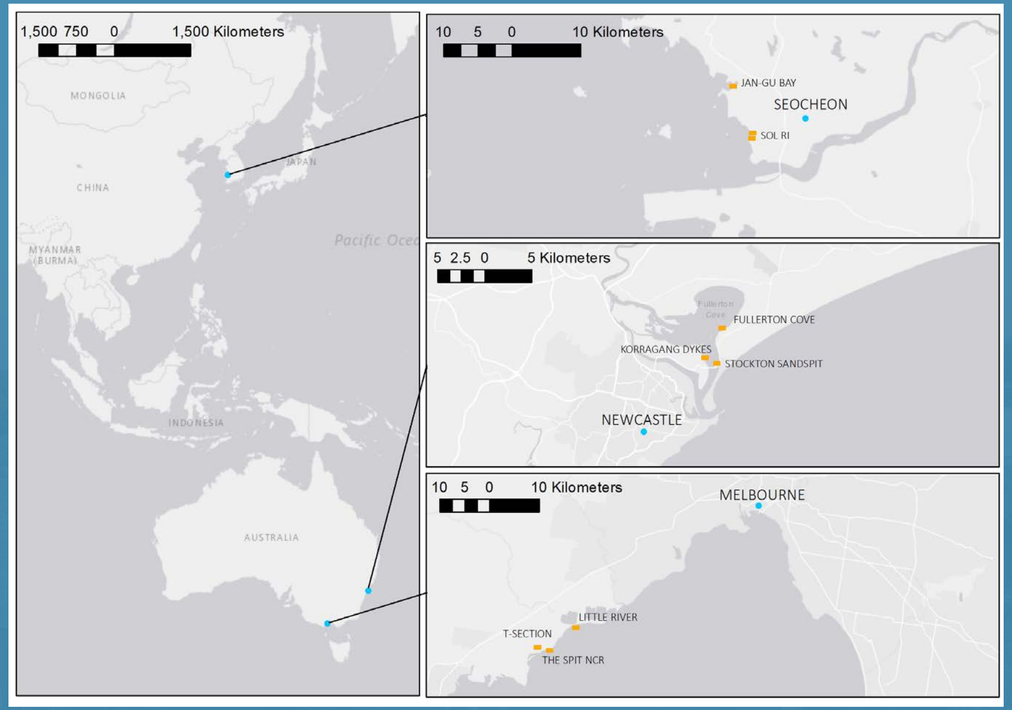
Given that floating roosts are considered a **last resort emergency intervention**, discussions should seek to address the feasibility of installing them in an appropriate site, whether floating roosts are likely to be effective for the target species and overcome the threats affecting natural roosts.

When selecting a deployment site within a region the following variables must be considered:

- Proximity to natural roosts
- Proximity to feeding areas
- Proximity to vegetation and tall structures
- Protection from wave action, wind and floating debris
- Likelihood of disturbance
- Existing water uses (e.g., boating, fishing)
- Access for installation and maintenance
- Access for monitoring
- Perceived necessity for additional roost capacity
- Site hydrology



# Site deployment




Floating roost trials were installed at three internationally significant shorebird habitats along the Flyway - Geum Estuary, Seocheon (top), The Hunter Estuary (middle) Port Phillip Bay (Bottom). Each site consisted of three roosts.

Sol Ri floating roosts (left) were situated in the last accessible roost site on the mainland coast. Sol Ri is bounded by seawalls and a dyked tidal creek.

Barry's Beach in the Hunter (right) is the only remaining open beach in Fullerton Cove due to mangrove incursion.

A roost in Port Philip Bay's Spit Nature Conservation Reserve (below) was installed in a small tidal lagoon sheltered by a chain of barrier islands and sand spits.


Phase 1 trials were conducted at three significant migratory shorebird habitats in the East Asian-Australasian Flyway:

1. Port Phillip Bay western shoreline, Victoria
2. Hunter Estuary, New South Wales
3. Geum Estuary, Seocheon County, Republic of Korea (ROK).

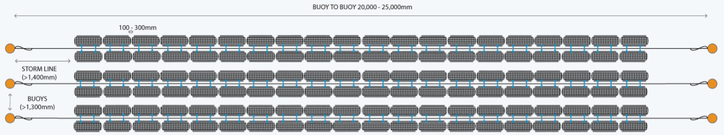
Australian trial sites were selected to provide a proof of concept before undertaking the Korean trial. Port Phillip Bay and Hunter Estuary are both recognised as Ramsar wetlands of international significance for their abundance of shorebirds and occurrence of threatened species. Both Port Phillip Bay and Hunter Estuary are peri-urban wetlands containing large areas of heavily modified habitat.

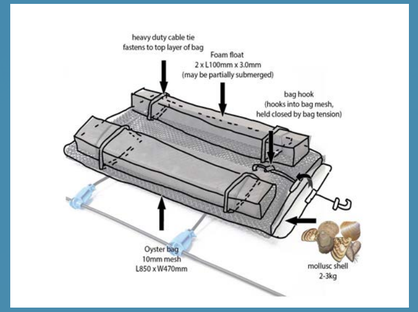
Local stakeholders identified that roost availability may be of management concern in the near future. Investment in established management interventions to mitigate current losses and build resilience for future losses is underway.

While traditional roost management methods continue to be implemented at these sites, floating roosts were deployed to trial supplementary measures.

The trial roost format was designed to be large enough to theoretically support a roost of several hundred birds but small enough that it could be easily deployed by small teams at several locations. Each parallel line of oyster bags was more closely spaced than commercial oyster farms to provide better thermal properties.

The initial trial is a proof of concept using commercially available equipment. The roosts are moored to marine grade screw anchors and attached to a super strong poly aqua storm line which is constructed from UV-treated polyester, displaying advanced hydroscopic properties with breaking strain 435 kg/ft-300mm. The bags are made of High Density Polyethylene (HDPE) and Linear Low Density Polyethylene (LLDPE) which make them both flexible yet strong and UV resistant.




# Deployment techniques and roost attributes

Deployment of a single roost can be undertaken by a small unskilled team (minimum two people) within a single day.

Deployment comprises:

- Filling bags with a subtrate to provide weight to the bags and a surface for potential prey to colonise.
- Screwing galvanised screw anchors into the sediment.
- Attaching the heavy-duty storm line to the anchors via buoys and marine grade rope.
- Attaching bags to the stormline.

Monitoring is best achieved through remote cameras. This enables the widest temporal sample size, reduces field excursions and disturbance. However the resolution of remote cameras may limit the ability to identify shorebirds down to species level.

Top left: Roosts are assembled on the intertidal flats before being towed out by hand at high tide.

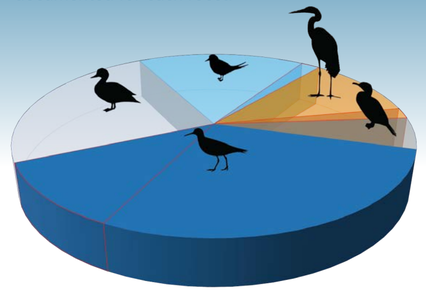
Bottom left: Trial configuration was consisant across all sites.

Above: Each long-line oyster bag is filled with mollusc shell to provide weight and invertebrate habitat.

Opposite, clockwise from top left: Screw anchors being installed on the Sol Ri intertidal flats.
Filling bags with mollusc shells.
Footage of waterbirds captured by remote cameras.
Long-line oyster bags *in situ*.

# Results

Remote video monitoring of the Port Philip Bay and Geum Estuary sites documented waterbird responses to floating roosts. Over 1,300 recordings were analysed and waterbird diversity, abundance and behavior were documented for each roost.



shorebirds | waterfowl | terns/gulls | herons/ spoonbill | cormorants | threatened species (red border)

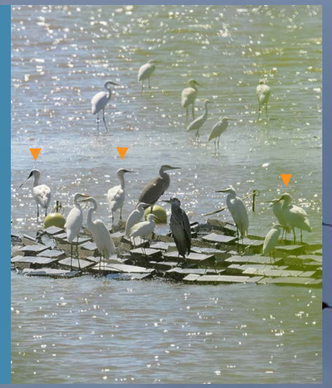
58

**In total 58 species of waterbirds*** were recorded using the roosts including 21 species of shorebirds. This comprised 35 species in Port Phillip Bay (including five migratory shorebird species and four residents) and 28 species in the Geum Estuary (including 14 migratory shorebirds).

*See appendix for species list.

7

**Seven threatened species** were observed using the floating roost including Eastern Curlew (Critically Endangered), Black-faced Spoonbill (Endangered IUCN, pictured right) in the Janhang coast and Fairy Tern (Vulnerable IUCN) in Port Phillip Bay were regularly recorded taking advantage of floating roosts. Threatened species action planning for these species may consider floating roosts as temporary management interventions.

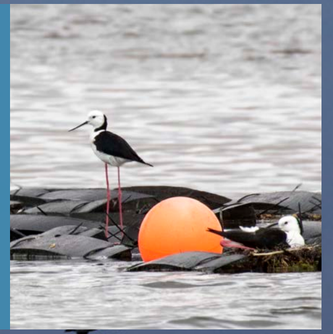


500

**Over 500 individual shorebirds** were observed using a single roost in Geum Estuary during southern migration (right). This is thought to be the capacity of any given roost in the current format as birds were observed jostling for position forcing some individuals to abandon roosting.

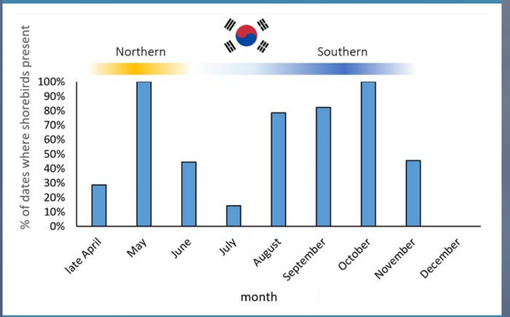
1

**One species of resident shorebird species attempted nesting on the roost.** Six pairs of White-headed Stilts attempted to nest on the Spit NCR roost (right). Although their fates were not recorded due to Covid restrictions, egg fragments were found in some of the remaining nests upon returning to site.



Shorebird use of the roosts varied between sites and seasons. Naturally the highest concentrations and rate of use occurred during peak migration in ROK.

Sites which were close to the last available roost site in a high tide cycle were more readily used than others.




The percentage of total dates where the Korean floating roosts occupied by migratory shorebirds from 19 April to 21 December 2019.

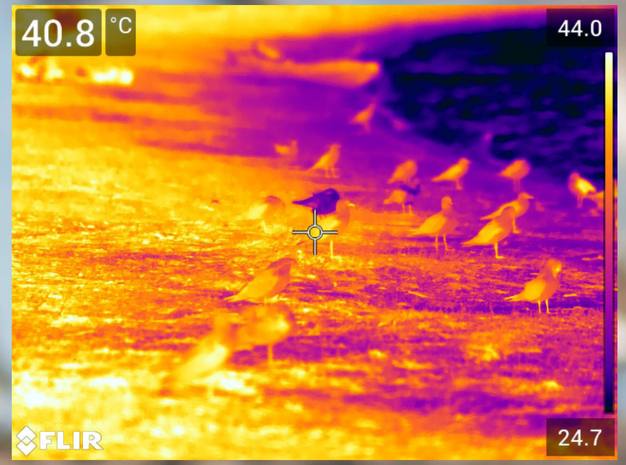
Migratory shorebird roost occupancy models that investigated the relationship between roost use and local abiotic variables identified that wind speed and the maximum daily tide were also important variables in predicting whether a floating roost was utilised. Birds were more likely to use the roost on days closest to spring tide, often taking to the roost before the water had even reached it.

# How floating roosts are being used: Predictors and thermal factors

One major drawcard which we suspect makes oyster farms and floating roosts attractive to shorebirds may lie right beneath their feet!

Shorebirds seek to maintain a stable body temperature to reduce energy expenditure. Much of the heat is exchanged through their bills and their legs and feet. This thermoregulation is normally achieved by roosting on wet sand or in shallow water.

We theorised that shorebirds may utilise the insulative and cooling effects of water afforded by the mesh structure of the roosts.

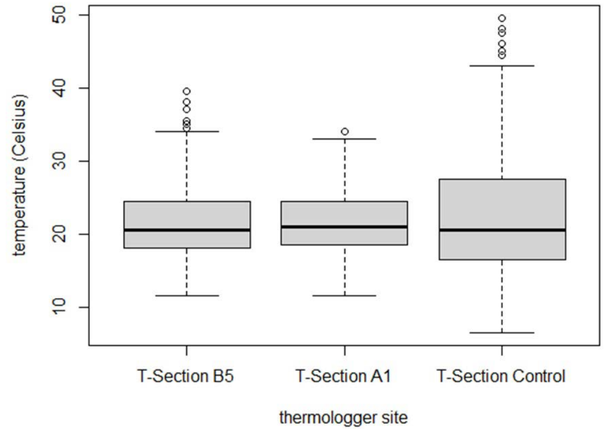



Thermal imagery of Silver Gulls roosting on a wetland shoreline. Photo Alexandra McQueen

To test the theory, we deployed thermologgers on floating roosts and nearby, natural roosts.

Results showed significant differences in two of the three pairwise comparisons. Natural roosts recorded a wider range of temperatures (both maximums and minimums) than the floating roosts. Natural roosts recorded almost three times as many temperature recordings over 30 degrees than their associated floating roost.

Thermologgers attached to the floating roost (left) and a small screw anchor at a natural roost at Port Philp Bay (right).




T-Section (Port Philip Bay) floating roost bag B15 temperature range plotted against that of the nearby control roost. 30 November 2018 – 29 January 2019

# A floating feast — fare and foul

By virtue of design long-line oyster bags provide excellent growing conditions for marine and intertidal communities. Indeed, oyster farmers need to regularly flip their bags to reduce the amount of “fouling” of oyster shells by invertebrates and they often complain about fish entering the bags as fry only to gorge themselves to the point that they are too big to exit through the mesh!

The floating roost trial sought to exploit this colonisation process in order to provide a floating food source for birds when intertidal flats are submerged. To facilitate colonisation, we filled the bags with oyster, mussel and scallop shells, each with high surface area for attachment and plenty of nooks to inhabit.

Basic sampling of the bags contents revealed several species of marine worms, crustaceans, molluscs and anemones had colonised the bags.

While initial studies indicate that diversity is not as high as within the adjacent mudflat, 34 shorebird and waterbird species were recorded regularly feeding on and around the roosts at both low and high tides.

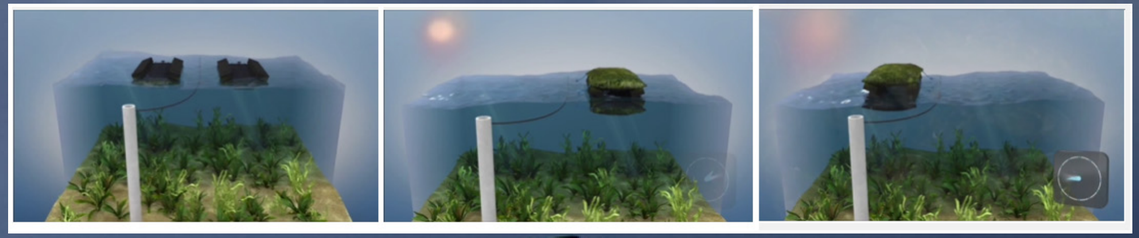
Bottom left: A Sharp-tailed Sandpiper feeds on the T-section floating roost

Top: Contents of the floating roost bags included bivalves, polychaetes and crustaceans.

Bottom right: Filter-feeding waders including Royal Spoonbill and Red-necked Avocet were recrded feeding in the water column around and between the roost lines.


Encouraging fouling of floating roosts introduced some unexpected issues for their maintenance. In Port Philip Bay one species of colonial marine worm formed dense tube matrices. The accumulated sediment was colonised by further species and some bags tripled in weight (top left & right). This additional burden sank some bags and put strain on the roost components as a whole (bottom right). In the Hunter, mangrove seedlings began to grow in the bags (bottom left).

These cases highlight the very localised ecology of these sites and the requirement for some level of monitoring and maintenance of floating roosts. In both cases, flipping the bags for a period of two weeks each side was sufficient to “reset” them, clearing them of most intertidal flora and fauna.



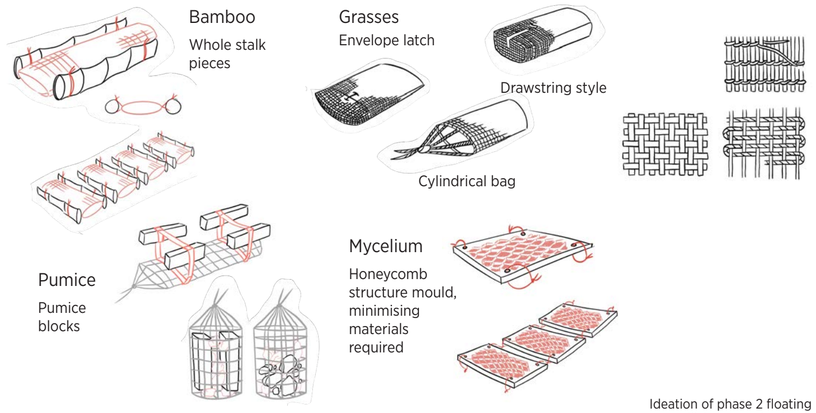
Flipping bags regulalry prevents fouling. Image: Zapco Aquaculture

# Phase Two of the floating roost trial

Phase 2 of the Floating Roost Trial will use our results to date to refine and optimise designs including improving thermal values and testing innovative non-plastic alternatives.

The project also hopes to engage experts from throughout the Flyway to:

1. Diversify trials to enable fit-for-purpose product realisation sooner.
2. Identify areas within the Yellow Sea World Heritage site which are in need of additional roost capacity and may benefit, even temporarily, from floating roosts.




Ideation of phase 2 floating roosts utilising non-plastic materials. Images: Lasna Tuschewski.

## A non-plastic future

Understanding that **any** plastics left in the ocean run the risk of potential small abrasions which contribute to marine microplastic. BirdLife Australia has teamed up with RMIT School of Design to investigate non-plastic alternative, replacing (currently HDPE/LLDPE) oyster-bags and foam float parts with natural materials.

Additionally engaging near-site production and manufacturing possibilities while ensuring alternate materials meet the durability and technical requirements.

Redesigned components and selected materials meet shorebird requirements, inclusive of:

- Environmentally benign material replacement
- Local Production
- Utilise techniques promoting local heritage
- Volunteer / D.I.Y engagement & production

# Discussion

## Floating roosts — silver bullet or bandaid?

Unfortunately, the spectre of climate change induced sea-level rise and increased exploitation of coastlines and waterways are only likely to increase pressure on shorebird roost site capacity. In addition to restoring or maintaining values, conservation managers are faced with the challenge of attempting to “future-proof” habitat by allowing for coastal retreat. Where natural habitat cannot be retained or ameliorated, artificial options – both supratidal and intertidal – should be explored.

The most effective roost is one that is available in all conditions but a mosaic of roosts of varying values also provides options to populations under differing scenarios. Any one roost may only be used as a supplementary or preferential site given a particular scenario (e.g. spring tide, disturbance, inclement weather) and in this respect if it is only used by part of a population for a short period each week, month or season it has played a role which has potentially prevented unnecessary energy expenditure or predation thus increasing capacity at other sites and adding resilience to the system.

Floating roosts have been effective in providing temporary respite for shorebirds at times of stress. This has been most evident in the highly modified coastline of the Korean Getbol but is there a need for them elsewhere in the Flyway?

The World Heritage listed Seocheon Getbol (Jianghang coast). Photo: Reuben Warren

We would like to reinforce that floating roosts are only intended to be used as a LAST RESORT EMERGENCY INTERVENTION. They are not equivalent in value to and should not be considered a substitute for natural habitat. Floating roosts should not be considered as a crutch to permantlay support a population nor should they be considered as an offset in justifying impacts to existing habitat. They should only be considered as part of a strategy to restore site value. In this respect they are a band-aid solution and once the wound has healed the band-aid should be removed.

The novelty of floating roosts may play a key role in raising awareness of the plight of shorebirds in our Flyway. There conspicuous appearance and mobility are already being considered for their eco-trousim potential at Korean sites.

BirdLife looks forward to continuing our exploration of the trials in partnership with the Australian Government and the Korean Ministry of Oceans and Fisheries and working more broadly to securing resilient coastal ecosystems into the future.


Interpretive signage on the seawall adjacent to the Sol Ri floating roosts, Seocheon Getbol (ROK). Photo: Young Min Moon.

# Appendices

Species observed roosting (R), or feeding (F) on floating roosts in the roost trials. Species appearing in pink were recorded using oyster leases in Merimbula Lakes, NSW. The project has also identified additional shorebirds regularly utilising oyster bags for feeding and roosting in Taunton Bay Maine USA .

| Species (Shorebirds) | Port Phillip Bay (AUS) | Geum Estuary (ROK) |
|---|---|---|
| Grey-tailed Tattler | | R |
| Sharp-tailed Sandpiper | R,F | |
| Terek Sandpiper | | R,F |
| Great Knot | | F |
| Common Sandpiper | | R,F |
| Bar-tailed Godwit | | R,F |
| Eurasian Curlew | | R |
| Far Eastern Curlew | | R,F |
| Whimbrel | | R |
| White-headed Stilt | R,F | |
| Banded Stilt | R,F | |
| Red-necked Avocet | F | |
| Ruddy Turnstone | | |
| Red Knot | | |
| Australian Pied Oystercatcher | | |

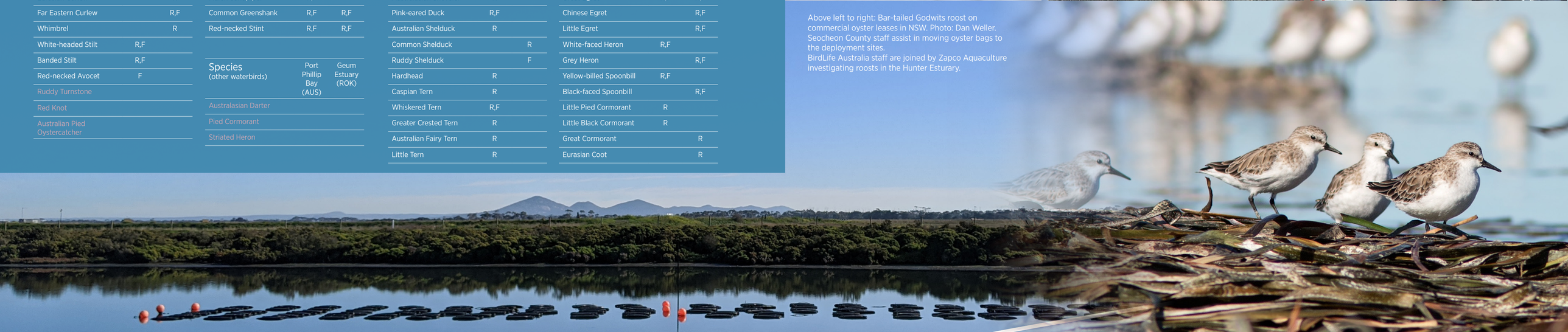
| Species (Shorebirds) | Port Phillip Bay (AUS) | Geum Estuary (ROK) |
|---|---|---|
| Lesser Sand Plover | | R |
| Grey Plover | | R |
| Masked Lapwing | R,F | |
| Broad-billed Sandpiper | | R |
| Dunlin | | R,F |
| Curlew Sandpiper | R,F | |
| Marsh Sandpiper | R,F | |
| Common Greenshank | R,F | R,F |
| Red-necked Stint | R,F | R,F |

| Species (other waterbirds) | Port Phillip Bay (AUS) | Geum Estuary (ROK) |
|---|---|---|
| Australasian Darter | | |
| Pied Cormorant | | |
| Striated Heron | | |

| Species (other waterbirds) | Port Phillip Bay (AUS) | Geum Estuary (ROK) |
|---|---|---|
| Black Swan | F | |
| Pacific Black Duck | R | |
| Mallard | | F |
| Eastern Spot-billed Duck | | R,F |
| Chestnut Teal | R,F | |
| Grey Teal | R,F | |
| Australasian Shoveler | R | |
| Pink-eared Duck | R,F | |
| Australian Shelduck | R | |
| Common Shelduck | | R |
| Ruddy Shelduck | | F |
| Hardhead | R | |
| Caspian Tern | R | |
| Whiskered Tern | R,F | |
| Greater Crested Tern | R | |
| Australian Fairy Tern | R | |
| Little Tern | R | |

| Species (other waterbirds) | Port Phillip Bay (AUS) | Geum Estuary (ROK) |
|---|---|---|
| White-winged Black Tern | | |
| Silver Gull | R,F | |
| Saunders' Gull | | R,F |
| Black-tailed Gull | | R,F |
| Herring Gull | | R,F |
| Pacific Gull | R | |
| Great Egret | R,F | R,F |
| Chinese Egret | | R,F |
| Little Egret | | R,F |
| White-faced Heron | R,F | |
| Grey Heron | | R,F |
| Yellow-billed Spoonbill | R,F | |
| Black-faced Spoonbill | | R,F |
| Little Pied Cormorant | R | |
| Little Black Cormorant | R | |
| Great Cormorant | | R |
| Eurasian Coot | | R |

Above left to right: Bar-tailed Godwits roost on commercial oyster leases in NSW. Photo: Dan Weller. Seocheon County staff assist in moving oyster bags to the deployment sites.
BirdLife Australia staff are joined by Zapco Aquaculture investigating roosts in the Hunter Esturary.



All photos in this booklet were taken by Chris Purnell unless otherwise noted.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