WELCOME

to our autumn edition of Envirotalk.

In this issue –

- The 2008 **Farmers Calendar** has been updated and re-printed
- Jeremy Madeiros summarizes some of the latest research on **Bermuda's national bird** (the cahow)
- Dr Mark Outerbridge teaches how to turn invasive **lionfish** into a delicious meal of fish and chips
- Dr Sarah Manuel explains how local **seagrass meadows** may be restored by planting seeds

Also See:

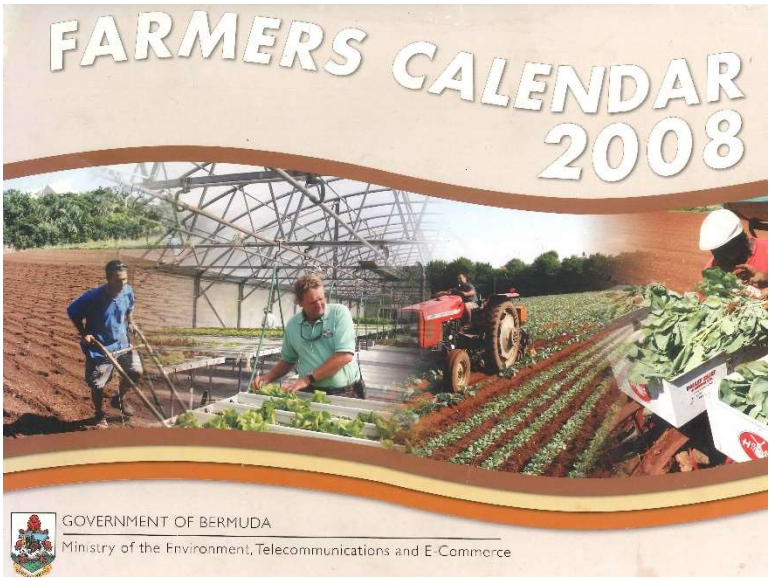
- Our **News & Notices** for reminders and upcoming events
- The **Planting Calendar** to get a head start on what to plant this autumn

Please contact the Envirotalk mailing list envirotalk@gov.bm if you would like to be added to it or if you wish to make suggestions for future articles.

Mark Outerbridge - Editor

THE FARMERS CALENDAR

The Farmers Calendar was published in 2008 and contained advice about what vegetables to grow during each calendar month, provided planting and production guides, explained how to store vegetables once they have been harvested, and gave short biographies on many of our local farmers. This calendar was so popular that DENR has decided to re-publish an updated version of it.



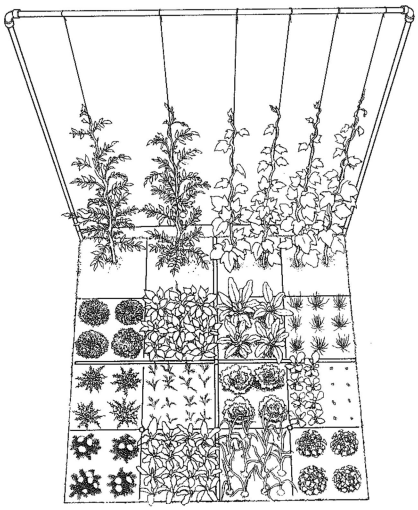
Farming has been one of Bermuda's traditional economic activities for more than 400 years. Our rich soils and mild climate allow for a huge range of fruits and vegetables to be grown almost all year round. In the 17th century, Bermuda's first colonists brought with them a wide variety of plants which were locally grown, including grape vines, oranges, lemons, bananas, figs, carrots, turnips, and beets. In later years, potato, cassava, sweet potato, hemp, flax, cotton, and indigo were imported and grown. The development of agricultural products as exports occurred early in Bermuda's history with the growing of tobacco, potatoes, corn, and citrus. Settlers in the fledgling colony of Jamestown, Virginia, were saved from starvation by a ship laden with meats, fruits, and vegetables from Bermuda in 1610. Did you know that the first bunch of bananas ever to be seen in the United Kingdom came from Bermuda in 1633 and were displayed in the shop window of Thomas Johnston on Snow Hill in London.

Agriculture waned in the late 1600s with the decline in tobacco exports and a long period of low vegetable productivity, but by the mid-1800s Bermuda experienced a revival of the agricultural industry and arrow root, lily bulbs, potatoes, and onions were exported to markets in New York City. By 1912, local agriculture was at its peak with approx. 3000 acres of land being farmed. At that time, fresh vegetables could be delivered to the East Coast of America faster from Bermuda than from Florida or California. However, the introduction of refrigerated rail containers meant that fresh produce could be transported quickly and economically from all parts of the United States. This, combined with the introduction of high tariffs and increasing competition from American farmers, gradually forced Bermuda produce out of markets in the United States. After 1942, farmers concentrated on growing solely for local consumption. Following the end of World War II, Bermuda's economy changed to become more dependent on tourism and international business. Rising land values tempted many land owners to sell off their agricultural land to builders for golf courses and housing developments. This meant that less land was available for cultivation and agriculture began to dwindle further.

The decline continues to this day. The low cost and ease with which produce can be imported, coupled with a lack of interest in entering the industry, has led to fewer young people becoming involved. Before 1930 Bermuda was a major exporter of vegetables; now approximately 80% of our fresh produce is imported. In 1987, 73 registered farmers farmed a total of 660 acres. In 2001, 46 farmers were registered

and the total land farmed commercially had decreased to approx. 380 acres. Not much has changed over the ensuing twenty years; the number of registered farmers has increased slightly to 51 (18 full time and 33 part time) while the number of acres being actively farmed has decreased to around 360 acres.

Locally grown produce is fresher, tastier, and has a much smaller carbon foot-print than imported products. Grow your own fruits and vegetables and support our local farmers by buying theirs. If space is an issue for you at home then considering farming the Square Food Garden[1,2] way instead of the traditional single-row method. Square foot gardening was popularized in North America during the 1980s by Mel Bartholomew and involves designing, planting, and maintaining a productive garden using one foot square grids. This system allows gardeners to maximize the most of a limited garden space while minimizing watering needs, soil conditioners, and labour. Seeds and seedlings are planted in carefully determined spaces and sprawling crops are grown vertically to save space. This system also allows gardeners to easily practice companion planting, crop rotation, succession planting, and inter-planting.



Conceptual square foot garden plot from Bartholomew (1981)

[1]Bartholomew, M. 1981. Square foot gardening. Rodale Press, Pennsylvania. 347 pgs.
[2]Bartholomew, M. 2018. All new square foot gardening. 3rd Ed. Cool Spring Press. 272 pgs.

Vegetable storage

It often happens that more produce is grown than is needed for immediate use. The question of storage should then be considered. Storing vegetables increases the value of the garden. Vegetable storage can be divided into three general categories; air temperature (cellar or basement), refrigeration, and freezing. Sort out the vegetables and select only the most intact for storage because bruising and wounds will lead to spoilage.

Air temperature storage: select a dark room and screen it from rats and mice. If storing potatoes, you must also screen it from insects (especially the tuber moth). The room should be well ventilated to prevent excessive dampness, which will cause decay.

Onions and garlic bulbs	3-4 months at room temperature
Potatoes	3-4 months
Pumpkin (whole) and winter squash	4 months
Sweet potatoes	2 months

Refrigeration: is useful for storing vegetable for short periods of time. Most modern appliances have a low temperature setting of 40-45 °F; the lower the temperature the longer the storage period. The use of sealed containers (e.g. plastic-ware) increases storage life. The following table summarizes the ideal refrigeration periods for a variety of common vegetables.

VEGETABLE	STORAGE PERIOD	VEGETABLE	STORAGE PERIOD
Artichoke	2 weeks	Kohlrabi	2 weeks
Beans	10 days	Leeks	3 weeks
Beets, topped	3 weeks	Lettuce	2 weeks
Broccoli	5days	Mustard greens	10 days
Brussels sprouts	3 weeks	Okra	2 weeks
Cabbage	6 to 7 weeks	Parsley	5 days
Cantaloupe	10 days	Parsnip	3 weeks
Carrots, topped	3 weeks	Peas	1 week
Cauliflower	10 days	Pepper	1 week
Celery	3 weeks	Radish	2 weeks
Collard	5 days	Spinach	10 days
Corn	5 days	Squash, summer	2 weeks
Cucumber	10 days	Strawberry	5 days
Eggplant	10 days	Swiss chard	10 days
Endive	10 days	Tomato – green	4 weeks
Kale	2 weeks	Turnip	2 weeks
		Watermelon	2 weeks

Freezing: frozen vegetables may be stored up to one year. To prepare vegetables for freezing, clean and cut as for eating, and then blanch in hot water. For blanching, use a large pot with a lid; one gallon capacity will suffice for most vegetables (or two gallons for large, leafy vegetables). Bring the water to a boil, place the vegetables in a colander or cheesecloth bag and immerse in the boiling water. Put the lid on the pot and begin counting the blanching time. Follow exactly the times given in the table below then remove the vegetables and place under cold running water. As soon as the vegetable is cool, drain all the water and pack them in freezing bags. Don't forget to clearly label the bags before placing them in the freezer.

Vegetable	Blanching time (minutes)	Cooking time before serving (minutes)
Asparagus	3	3-5
Beans (sliced)	3	5-7
Beets	Until tender	Reheat
Broccoli	4	3-5
Brussel sprouts	4	4-6
Cabbage (wedges)	2	9-10
Carrots (cut)	3	4-6
Cauliflower	3	3-5
Chard	2	3-4
Corn (on the cob)	9	3-5
Eggplant (sliced)	4	Reheat
Kale (diced)	2	3-4
Kohlrabi (diced)	1	7-8
Mustard greens	3	3-4
Parsnips (sliced)	1	7-8
Peas	2	3-5
Potatoes (fries)	2	Bake, air fry, or deep fry
Pumpkin (diced)	Until tender	Reheat
Rutabaga (diced)	1	7-8
Spinach	2	3-4
Summer squash (sliced)	2	7-8
Turnip (sliced)	2	7-8

Planting guide

VEGETABLE	TIME TO PLANT	TRANSPLANT?	DISTANCE BETWEEN ROWS (IN INCHES)	DISTANCE IN ROWS (IN INCHES)
Artichoke	October to November	Yes	48	36
Asparagus	October to November	Yes	12	24
Beans, broad	November to February	No	9	9
Beans, bush	All year	No	24	3
Beans, pole	August to June	No	18	18
Beans, runner	October to November	No	18	18
Beet	October to April	Either	15	3
Broccoli	August to April	Yes	24	24
Brussels sprouts	August to January	Yes	24	24
Cabbage	August to April	Yes	24	18
Cabbage, Chinese	October to February	Yes	18	12
Carrots	July to April	No	18	2
Cassava	January to March	No	72	36
Cauliflower	September to April	Yes	24	18
Celeriac	September to February	Yes	18	6
Celery	September to February	Yes	12	6
Chard	September to April	Yes	18	12
Chicory	October to November	No	18	6
Chives	October to December	Yes	12	4
Christophine	January to April	No	72	72
Collard	March to April	Yes	18	6
Corn	February to April	No	36	12
Cucumber	Feb. to Jun., Sept. to Oct.	No	60	60
Dasheen	October to June	No	36	18
Eddoe	October to June	No	36	18
Eggplant	Sept. to Oct., Mar. to Apr.	Yes	36	36
Endive	Sept. to April	Yes	18	10
Garlic	September to October	No	12	4
Kale	August to April	Yes	18	15
Kohlrabi	August to April	Yes	12	6
Leek	August to March	Yes	12	4

VEGETABLE	TIME TO PLANT	TRANSPLANT?	DISTANCE BETWEEN ROWS (IN INCHES)	DISTANCE IN ROWS (IN INCHES)
Lettuce	October to March	Yes	12	12
Muskmelon	March to April	No	60	60
Mustard greens	August to March	Yes	18	12
Okra	March to May	No	36	18
Onion	October to November	Yes	12	4
Onions, spring	September to January	No	12	–
Parsley	September to November	Yes	18	6
Parsnip	Sept. to Oct., Mar. to Apr.	No	18	3
Peas	November to March	No	6	11/2
Peas, edible podded	November to March	No	6	11/2
Pepper	Mar. to Apr., Aug. to Oct.	Yes	18	18
Potatoes	September to March	No	24	9
Pumpkin	February to May	No	120	120
Radish	August to May	No	12	1
Rutabaga	August to April	Yes	18	6
Salsify	September to March	No	12	2
Scorzonera	September to March	No	12	2
Shallots	October to February	No	12	3
Squash	October to February	No	12	4
Spinach, N.Z.	October to April	No	24	12
Squash, bush	March to June	No	36	36
Squash, running	March to June	No	72	72
Strawberry	October to December	No	10	10
Sweet potato	February to May	Either	24	12
Thyme	October to November	Yes	12	12
Tomato	All Year	Yes	18	18
Turnip	September to April	No	18	4
Upland Cress	October to March	No	12	4
Watercress	October to February	No	–	–
Watermelon	March to April	No	96	96

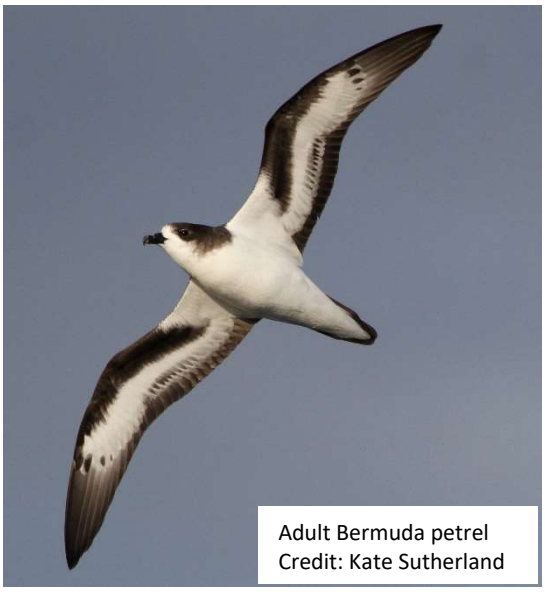
Production guide

The following tables summarize planting quantities (single-row method), estimated production amounts, germination times, and time to harvest for the most commonly grown herbs and vegetables on Bermuda:

VEGETABLE	LENGTH OF ROW PER PLANTING FOR AVG. FAMILY	ESTIMATED PRODUCTION	AMOUNT OF SEED	DAYS TO GERMINATE	WEEKS TO MATURITY
Artichoke	12 ft (4 plants)	32 buds	¼ pkt	7–21	26–35
Asparagus	50 ft	15 lbs.	½ oz	21–28	3 years
Beans, broad	25 ft	20 lbs.	2 oz	4–14	17–24
Beans, bush	25 ft	11 lbs.	2 oz	5–8	6–9
Beans, pole	25 ft	16 lbs.	1 oz	5–8	8–11
Beans, runner	25 ft	16 lbs.	1 oz	5–9	8–12
Beet	15 ft	15 lbs.	½ pkt	3–14	7–12
Broccoli	20 ft (10 plants)	8 lbs.	1/8 pkt	3–10	10–21
Brussels sprouts	20 ft (10 plants)	4 lbs.	½ pkt	3–10	12–21
Cabbage	8 ft (6 plants)	20 lbs.	1/8 pkt	3–10	9–17
Cabbage,	12 ft (12 plants)	12 heads	½ pkt	3–7	9–11
Carrots	20 ft	20 lbs.	½ pkt	6–21	10–15
Cassava	9 ft (3 plants)	8 lbs.	3 cuttings	–	2 years
Cauliflower	14 ft (9 plants)	15 lbs.	1/8 pkt	3–10	12–14
Celeriac	10 ft	20 stalks	1/8 pkt	10–21	17–22
Celery	4 ft (6 plants)	6 stalks	1/8 pkt	10–21	17–22
Chard	10 ft (10 plants)	9 lbs.	1/8 pkt	3–14	9–13
Chicory	10 ft	2 lbs.	¼ pkt	5–12	12–15
Chives	5 ft (15 plants)	15 bunches	1/8 pkt	6–14	11–15
Christophine	12 ft (2 plants)	12 fruit	2 fruit	–	2–16
Collard	10 ft (12 plants)	8 lbs.	1/8 pkt	3–10	10–14
Corn	30 ft	50 ears	1 oz	4–7	10–14
Cucumber	10 ft (2 hills)	6 lbs.	¼ pkt	3–7	10–14
Eggplant	9 ft (3 plants)	15 fruit	1/8 pkt	7–14	10–14
Endive	5 ft (6 plants)	6 heads	1/8 pkt	5–14	12–14
Garlic	4 ft	12 bulbs	12 cloves	–	22–29
Kale	13 ft (10 plants)	10 heads	1/8 pkt	3–10	9–14
Kohlrabi	6 ft (12 plants)	12 stems	1/8 pkt	3–10	6–9
Leek	15 ft (45 plants)	45 stems	½ pkt	6–14	14–21

VEGETABLE	LENGTH OF ROW PER PLANTING FOR AVG. FAMILY	ESTIMATED PRODUCTION	AMOUNT OF SEED	DAYS TO GERMINATE	WEEKS TO MATURITY
Lettuce	15 ft (15 plants)	15 heads	1/8 pkt	7	9–12
Mustard Greens	10 ft (10 plants)	5 lbs.	1/8 pkt	3–7	6–9
Okra	10 ft	10 lbs.	2/3 pkt	4–14	7–9
Onion	30 ft (120 plants)	25 lbs.	1 pkt	6–10	21–29
Parsley	2 ft (4 plants)	6 bunches	1/8 pkt	6–28	13–21
Parsnip	10 ft	7 lbs.	½ pkt	6–28	13–21
Peas	50 ft	14 lbs.	¼ lb.	5–8	10–14
Peas, edible podded	50 ft	14 lbs.	¼ lb.	5–8	10–14
Pepper	10 ft (6 plants)	6 lbs.	1/8 pkt	6–14	14–19
Potatoes	50 ft	50 lbs.	5 lbs.	10–18	12–17
Pumpkin	20 ft (2 hills)	60 lbs.	¼ oz	4–7	15–17
Radish	5 ft	3 lbs.	1/8 pkt	4–6	3–6
Rutabaga	10 ft (20 plants)	10 lbs.	1/8 pkt	3–14	14–17
Salsify	10 ft	7 lbs.	½ pkt	6–21	17–21
Scorzonera	10 ft	7 lbs.	½ pkt	6–21	17–20
Shallots	6 ft	6 lbs.	24 cloves	–	21–29
Spinach, N.Z.	30 ft	10 lbs.	1 plot	5–28	10–12
Squash, Summer	8 ft (2 hills)	12 fruit	½ pkt	4–7	7–11
Squash, Winter	32 ft	10 fruit	1 pkt	4–7	12–14
Strawberry	15 ft of bed	20 qts.	100 plants	–	10–14
Sweet potato	20 ft	20 lbs.	8 potatoes	–	17–21
Thyme	2 ft	–	¼ pkt	6–14	12–20
Tomato	18 ft (12 plants)	40 lbs.	1/8 pkt	5–14	13–17
Turnip	10 ft	10 lbs.	1/4 pkt	3–7	6–7
Upland Cress	10 ft	6 bunches	¼ pkt	3–7	6–7
Watercress	4 sq. ft	4 bunches	½ pkt	4–14	7–10
Watermelon	16 ft (2 hills)	8 melons	½ pkt	4–14	12–14

CAHOW RESEARCH PROVIDES INSIGHTS INTO OCEAN DYNAMICS AND HEALTH



Adult Bermuda petrel
Credit: Kate Sutherland

The Bermuda petrel, or cahow (*Pterodroma cahow*) is one of the rarest seabirds on Earth, and is Bermuda's official National Bird. It is endemic to Bermuda, nesting nowhere else on Earth other than six small islands in the Castle Harbour area, totaling only 22.5 acres in area. The story of the cahow is well-known, being one of almost miraculous survival, after being thought extinct for over 330 years, from the 1620s to the re-discovery of a small number of nesting pairs on a few tiny rocky islets off the east end of Bermuda in 1951. Since 1960, the cahow has been the subject of a recovery program that has successfully controlled most threats facing the species on its nesting islets. This has enabled the cahow to increase in number from only 18 breeding pairs producing a total of only 7-8 fledged chicks per year in 1960, to a new record number of 164 breeding pairs producing 76 successfully fledging chicks in 2023. The recovery program has also been successful in establishing two new nesting colonies of cahows on the Nonsuch Island Nature Reserve. This island is much larger (16.5 acres) and more elevated than the original four tiny nesting islets, which total only 2.4 acres in area and have become increasingly impacted and vulnerable to hurricane flooding and erosion and sea-level rise.

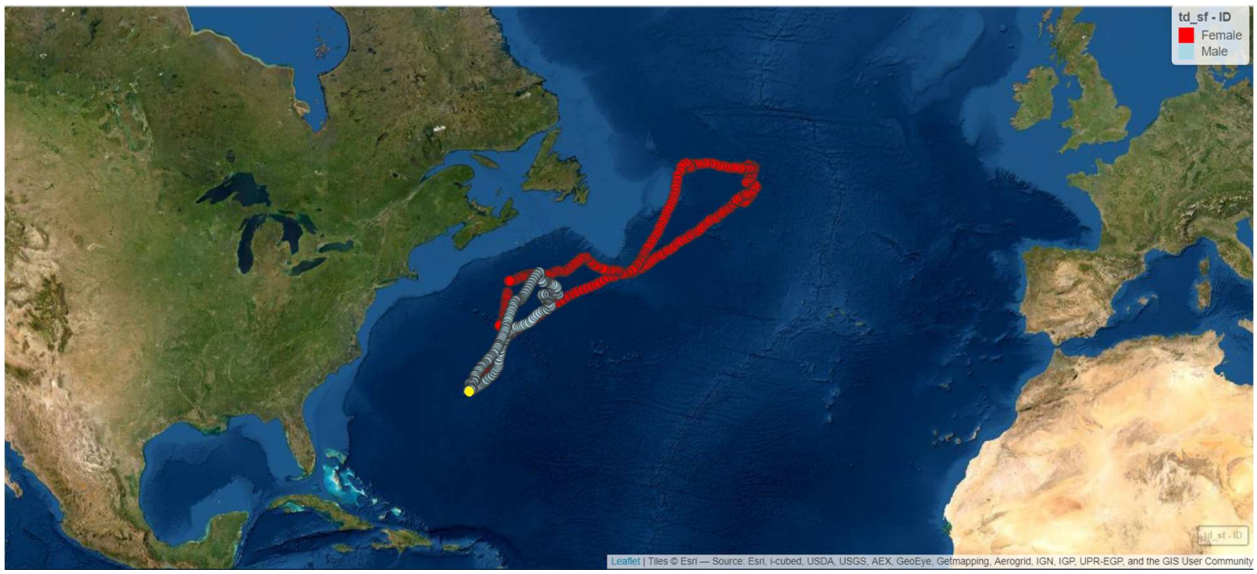
Since 2019 I have carried out collaborative research studies with a number of overseas scientists, including Letizia Campioni (MARE IPSA) from Italy, Maria Silva from the University of Lisbon, Portugal, Carina Gjerdrum (Canadian Department of Environment and Climate Change), and Andre Raine (U.S. Kauai Endangered Seabird Recovery Project). Work undertaken during that period was extremely varied, despite being impacted by the Covod-19 pandemic, and has provided valuable new information about cahow biology and the specie's position within the greater North Atlantic biome. Here is a brief summary:

GPS tag fixed to the tail feathers of an adult cahow. Credit: JP Rouja

<u>Satellite telemetry</u>

A total of 43 adult breeding cahows were fitted with NANO GPS logger tags, small devices weighing only 3.4 grams, which were attached to the central tail feathers using TESA tape. These tags tracked the foraging trips of the adults during the egg incubation (early January to late February) and early chick-rearing periods (early March to mid-April). Cahows have a "tag-team" approach during egg incubation; one adult stays in the underground nest burrow incubating the egg while the other goes to sea to feed, after which the foraging bird returns to take over incubation while the other goes to feed. Later, during chick-rearing, both adults carry out lengthy foraging trips to gather food for their growing, ever-hungry chick. They only spend a few hours with the chick during the feeding visits and return immediately to the open ocean to continue foraging. The chick spends almost all it's time alone in the nest burrow except for these brief night visits. Petrels like the cahow are fast-flying, dynamic seabirds

that perform extremely long-distance foraging trips which cover vast areas of ocean. These trips can reach almost unbelievable distances from the nesting colonies; one GPS tag revealed a maximum one-way distance of 3,185 km (1,979 miles) during a single foraging trip while the average one-way distance flown was 1,462 km (908.4 miles). The amount of time spent at sea during such foraging trips was higher during egg incubation (270 hours or 11 days 6 hours) than during early chick-rearing (152 hours or 6 days 8 hours). This is obviously due to the need to feed the chick regularly. Observations carried out over the past two decades show that cahow chicks are fed on average only 2-3 times a week, with both male and female adults sharing feeding duties (and egg incubation) equally. When the chicks are fed, they are given large meals of semi-digested food regurgitated directly from the beak of the adult into the chick's beak. This can result in a chick almost doubling its weight following a feeding visit.



Map showing one round-trip foraging journey for a female (red track) and male (grey track) cahow while rearing a chick on Bermuda (yellow dot).

Diet

Adult cahows occasionally regurgitate food when handled by a human researcher. Genetic barcoding analysis of these semi-digested food items has revealed that cahows are ocean predators who target deep water species from the mesopelagic (mid-water) and bathypelagic (deep-water) zones of the ocean. The taxonomic diversity was remarkable, and included 16 fish and six squid species. These prey are presumably taken at night during diurnal vertical migration when many species that normally live at depths of 1000 m or more migrate to the surface to feed on plankton before returning to the depths before sunrise. Overall, the results contribute critical new knowledge on the foraging behavior plasticity of the cahow, which can help to predict how a small population of an endangered species responds to climate-related changes in wind patterns and oceanic processes in the North Atlantic Ocean. This is likely to become more important in the future as climate change becomes more prevalent and will increasingly impact species through changing prey distribution and availability.

Eco-toxicology

Blood and feather samples (121 and 90 respectively) were collected and tested for sex hormones, stable isotopes, and for the presence of persistent organic pesticides (POPs). A variety of organochloride pesticides (chemicals used extensively in agriculture and mosquito control during the mid-20th century) were encountered; DDT was confirmed in less than 30% of the samples but DDE (a common breakdown

product from DDT) was confirmed in all of the samples. The presence of DDT and DDE is a cause for concern because both affect calcium uptake in various bird species which results in thinner eggshells that are more easily broken during incubation. Hexachlorobenzine (HCB) was detected in more than 50% of sampled cahows. This organochloride is carcinogenic, teratogenic (causes birth defects), and may cause embryonic death. These findings may partly explain why there is a relatively high level of egg failure in Bermuda's breeding population of cahows (41%-52% each year). DDT was banned in the 1970s and HCB was banned in 2001, however these fat-soluble chemicals have the ability to persist within the environment and bio-accumulate within organisms. On a positive note, few traces of either polychlorinated biphenyls (PCBs) or polybrominated diphenyl ethers (PBDEs) were found and the amounts of trace metals such as mercury (Hg) and lead (Pb) were not high enough to cause any concern.

These results show how highly mobile oceanic predators, like the cahow, are using the deep oceanic environment, how they are being affected by long-lasting pesticides that wash into oceanic basins from surrounding continents, and give insights into how seabirds and their prey are reacting and adapting to climatic and oceanic change. It has also provided clear evidence that cahows regularly forage within the territorial waters of Canada (the edges of the Nova Scotia and Newfoundland Shelf), which has led to a proposal to have the cahows declared as a Canadian Endangered Species. This is important for the continued recovery of the cahow because there are numerous areas along the Nova Scotia Shelf that have been identified for oil and gas exploration and the intense lights and gas flares associated with offshore oil platforms tend to attract seabirds which leads to collision injuries.

Geolocator tag attached to the leg of a fledgling cahow. Credit: JP Rouja

In 2022, 37 fledgling cahows were fitted with archival GLS Geolocator tags on their legs shortly before they departed. These tags last longer than the GPS tags and are retrieved after the birds have matured and returned to the nesting colony (some 3-5 years later). We have been developing a fairly good understanding of the oceanic range and main feeding areas used by adult cahows, but we have no idea where newly fledged birds go. Do they use the same areas as the adults? Do they explore the ocean basin more widely to build a map in their memories of productive oceanic areas at different times of the year? The first of these tagged birds should return over the next 2-3 years and hopefully begin providing answers to some of these questions.

In conclusion, this collaborative research program is now revealing important new knowledge, not only to Bermuda's critically endangered National Bird, but for other oceanic species and the greater North Atlantic ecosystem.

Jeremy Madeiros
Principle Terrestrial Conservation Officer

EATING INVASIVE SPECIES: LIONFISH AND CHIPS

Invasive species have the ability to become established in a novel environment and subsequently proliferate at which point they are highly likely to cause damage to natural ecosystems, cause economic harm, and some can even threaten human health. The adverse impacts of invasive species are considered to be the single greatest threat to island native biodiversity[1] because island species have evolved largely in the absence of mainland predators, heavy competition, and diseases. Island species can readily fall victim to invasive species; they make easy prey and fail to effectively compete for resources like food and space. Invaders, on the other hand, encounter better resources, fewer natural enemies and a more advantageous physical environment to live in. As a result, they not only displace native species, but can also alter whole ecosystems by disrupting ecosystem services, changing light levels and soil chemistry, affecting nutrient cycling, competing for limited resources and acting as predators. Aside from their negative impacts on native biodiversity, invasive species often impose an economic cost on agriculture, fisheries, and infrastructure.

Since the arrival of the first human visitors in the sixteenth century, Bermuda has experienced a continual procession of invaders. At least 1,400 exotic species having become naturalized in our environment (meaning they are established and reproducing). The dramatic increase in global trade and travel over the last several decades has led to rapid acceleration of invasive species movement. Now, as never before, exotic plants and organisms are traversing the globe, borne on the swelling tide of human traffic to places where nature never intended them to be.

In this issue, and in the next few issues, DENR will highlight edible invasive species which have become naturalized within Bermuda's environment. We will provide brief biographies and recipes for each that we hope will stimulate both the reader's interest and appetite. The phrase "*Eat 'em to beat 'em*" was coined during the campaign to remove lionfish from local waters and applies equally well to other delicious tasting invasive species.

Lionfish (*Pterois volitans* and *Pterois miles*) have been present in local waters for at least 23 years, however they are not indigenous to the Atlantic Ocean. These exotic species from the Indo-Pacific first made their appearance off the coast of Florida in the 1980s and have steadily spread across the Western Atlantic inciting concerns about their potential invasiveness. Local research has revealed that lionfish form relatively dense aggregations on Bermuda's mesophotic coral reefs (approx. 200 feet in depth) where colder-water upwelling currents may transport nutrients which fuel the food chain, resulting in high abundances of prey[2]. Lionfish are generalist predators with a broad diet, consuming large quantities of small fishes and invertebrates (typically shrimps, crabs, and lobsters). Bermuda's lionfish prey heavily upon red night shrimp *Cinetorhynchus rigens*, bluehead wrasse *Thalassoma bifasciatum* (an ecologically important species which removes external parasites from other fishes), and Atlantic creolefish *Paranthias furcifer* (an economically important species in the fisheries industry)[3]. Stable isotope analyses[4] have confirmed that lionfish are top level predators whose diet is derived primarily from the plankton-based food web rather than from food

chains supported by macroalgae. This puts them in direct competition with coneys *Cephalopholis fulva*, squirrelfish, red hinds *Epinephelis guttatus*, yellowtail snappers *Ocyurus chrysurus*, and juvenile Galapagos sharks *Carcharhinus galapagensis*[4]. Additional studies have shown that Bermuda's lionfish appear to have a six month reproductive season (June-November) and grow to comparatively larger sizes than they do elsewhere within their invaded range[5].

Lionfish can be caught on a hook and line but the most assured way to get them is to jump into the ocean with a set of snorkeling gear and a spear. These fish can be caught year-round but it is during the winter months (i.e. November-February) when they are most abundant inshore. The majority of the reported landings on Bermuda occur in shallow waters well within one mile of the coast (see www.lionfish.bm/lionfish-hunting) so residents must obtain a special permit in order to spear them this close to shore. The permit also allows hunting with SCUBA equipment and within marine protected areas. Training courses are regularly held throughout the year. To find out when the next one will occur please contact permits@lionfish.bm or visit www.facebook.com/BermudaLionfishCullingProgram.

Lionfish are not poisonous; they are venomous, and the venom is only found in the spines of the fish, not in the flesh. It's therefore advisable to remove all the spines with a pair of heavy scissors before filleting. The REEF Environmental Education Foundation has created a short video showing how to safely fillet a lionfish (see www.youtube.com/watch?v=dTpI27ILFBE). Lionfish flesh is firm, white, flaky, and higher in healthy omega-3 fatty acids than many other commonly consumed fish. Furthermore, they also have very low amounts of mercury[6,7] and ciguatoxins[8] when compared to many other edible fishes. The fillets lend themselves to a variety of tasty dishes and hold up well to frying, grilling, steaming, and baking. The following recipe is for deep fried, beer battered lionfish.

Ingredients:
One pound of lionfish fillets (skin and bones removed)
½ cup sifted white flour
1 tablespoon of rice flour (optional)
¼ teaspoon of baking powder
½ bottle of ice cold beer
Pinch of salt (or Old Bay seasoning if preferred)


Internet image

Preparation:

- Mix together the flour, rice flour, baking powder, and salt.
- Slowly pour in the beer, mixing together well (the batter should be just thick enough to completely coat the back of a spoon).
- Pat the fillets dry with paper towel, coat them in a light dusting of flour and tap off the excess.
- Dredge the floured fillets through the batter.
- Place in hot oil (350°F) and fry for 5-6 minutes, turning once.

Serve with your favourite chips, coleslaw, and tartar sauce.

For additional inspiration watch local chef Alfred Konrad turn fresh lionfish into ceviche, jerk lionfish tacos, and lionfish tempura (www.youtube.com/watch?v=MNj-AyXfGmc). Please also visit

www.lionfish.bm/what-you-can-do for chowder, ceviche, and beurre blanc recipes supplied by Chris Malpas and Paul Lawrence.

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Dr Mark Outerbridge
Senior Biodiversity Officer

SEED-BASED SEAGRASS RESTORATION

If you have been out snorkeling around some of our inshore bays and islands this summer you may have noticed that in some areas the seagrass is recovering. This is great news! Sadly though, many areas that were once lush seagrass meadows are still bare sand. You may also have observed that there are far fewer green turtles around than there were previously[1] to eat the seagrass, and this is likely why the seagrass has been able to recover.


Manatee grass

The seagrass we are seeing the most is called manatee grass (*Syringodium filiforme*) and in some locations it is long, dense, and inhabited by lots of juvenile fish. There are some small areas where turtle grass (*Thalassia testudinum*) has managed to survive over the years and that is lush too. Manatee grass has a couple of characteristics that allows the plant to recolonize an area relatively quickly once a disturbance, such as turtle grazing, has been removed. It is a fast growing, flowering plant that produces hard-coated seeds during the summer months. This tough exterior allows the seeds to persist in the sediment in a dormant state, only germinating when conditions are right. Turtle grass does not have these characteristics and therefore cannot recolonize an area very quickly.

Some countries in temperate regions have a seagrass called eel grass, or *Zostera*, which has similar characteristics to manatee grass. Conservationists have been collecting *Zostera* seed and successfully using it to restore their denuded seagrass meadows[2,3]. After the Marine Conservation Section observed manatee grass with lots of fruit last summer in local waters we began to think that it may be possible to use manatee grass seed to colonize some of the bare areas of sand that were once seagrass meadows.

This summer Miss Treiana Zuill, working in collaboration with the Marine Conservation Section, began to study the sexual reproduction of manatee grass in Bermuda. Treiana is a Bermudian PhD student at Florida International University and for her PhD research she plans to explore the viability of using manatee grass seed for restoring seagrass meadows. Methodology for seed-based restoration of manatee grass will not only be useful for Bermuda, but other tropical areas where manatee grass grows. Bermuda is an ideal location to develop these methods because, unlike many places around the globe where seagrasses are in decline, our seagrass loss was not driven by declining water quality[4].


female flowers


male flowers

Manatee grass is a perennial plant with distinct male and female flowers. Treiana monitored areas of manatee grass at three sites to determine when they flowered and then followed the development of the female flowers through to the fruiting stage. The peak period of manatee grass flowering events this year was in late May and fruits were first observed on the plants in early June. Now we are waiting to see how long it takes for the fruit to ripen. Once fully ripened, seeds will be collected for planting. Small mesh bags have been tied over a number of reproductive shoots bearing fruit to catch the seeds when they mature and drop from the plant. These are being monitored regularly.

In mid-May sediment samples were collected near the manatee grass meadows at Marshall's Island in the Great Sound. The sediment was sieved through a fine mesh and the mesh was examined for grass seeds. Seeds were present and these were planted in pots of sand placed underwater in a cage. When the seeds were planted we did not know how long it would take for the seeds to sprout or if they were even viable because we do not know how long they have been buried in the sediment. We also do not know how long it takes for the new manatee grass seeds to germinate in Bermuda's marine environment, or what triggers them to sprout. These are all questions that Treiana will be trying to answer in the course of her PhD research. There is very little scientific literature about the germination of manatee grass from seed but by the end of June, 6% of the seeds collected around Marshall's Island had sprouted. These seedlings have continued to grow. While this is definitely not a high success rate, it is an encouraging start.

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Dr Sarah Manuel
Senior Marine Conservation Officer

NEWS & NOTICES

Spearfishing statistics reminder

Recreational spear fishers are reminded that spearfishing statistics should be submitted monthly using the online portal at www.fisheries.gov.bm. There should be an entry for each date and location that you fished, and a "No fishing" entry for the final day of any month in which you did not fish. Please call 293-5600 or send an email to fisheries@gov.bm if you are having difficulties accessing the portal.

Lobster diving reminder

Now that lobster season has begun, recreational lobster divers are reminded that they should fly a standard red and white dive flag when they are diving for lobsters, and must avoid diving in the vicinity of commercial lobster traps. Catch statistics must be reported using the online portal mentioned above and a report of "No fishing" should be submitted for any month in which there was no lobster diving activity. Keeping lobster catch statistics up to date through the season helps improve accuracy, particularly when it comes to reporting locations, and avoids a rush or complications as the reporting deadline of April 30th approaches. Please call 293-5600 or send an email to fisheries@gov.bm if you are having difficulties accessing the portal.

Seasonally closed protected areas

The extended closure areas, known as the 'grouper boxes', within the North Eastern and South Western Seasonally Closed Areas are currently closed to fishing, and will remain closed through the 30th of November 2023. The coordinates for these areas can be found at: https://www.gov.bm/bermudas-no-fishing-areas

PLANTING CALENDAR – WHAT TO PLANT IN THE AUTUMN

VEGETABLES, HERBS, & FRUIT

September

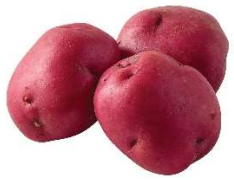
Beans, broccoli, Brussel sprouts, cabbage, carrots, cauliflower, celery, chard, cucumber, eggplant, kale, leeks, mustard greens, parsley, pepper, potatoes, radish, rutabaga, tomato, turnip.

October

Beans, beets, broccoli, Brussel sprouts, cabbage, carrots, cauliflower, celery, chard, chives, cucumber, eggplant, endive, kale, leeks, lettuce, mustard greens, onions, parsley, pepper, potatoes, radish, rutabaga, spinach, squash, strawberries, thyme, tomatoes, turnip.

November

Beans, beets, broccoli, Brussel sprouts, cabbage, carrots, cauliflower, celery, chard, chives, kale, leeks, mustard greens, onions, parsley, potatoes, radish, rutabaga, spinach, squash, strawberries, thyme, tomatoes, turnip.




FLOWERS

September

Celosia, cosmos, gazania, globe amaranth, impatiens, marigold, salvia, snow-on-the-mountain, vinca and zinnia.

October & November

Ageratum, antirrhinum, aster, aubrieta, begonia, bells of Ireland, candytuft, carnation, centaurea, chrysanthemum, cineraria, dahlia, dianthus, geranium, gerbera, gypsophila, impatiens, larkspur, lathyrus, nasturtium, nicotiana, pansy, petunia, phlox, rudbeckia, salpiglossis, salvia, statice, snow-on-the-mountain, spider flower, star-of-the-veldt, stock, sweet william, verbena and viola.