# LS1202 Assignment - 01

Submitted By: Priyanshu Mahato
Roll No.: pm21ms002
Date: June 21, 2022

Q1. Which characteristics of lionfish helped them successfully invade the Atlantic Ocean?

Ans. Lionfish are hardy creatures able to survive in tropical and subtropical water, from 10-foot to 500-foot depths. Through their voracious appetite and reproductive habits, lionfish have reduced the number of native fish and prevented juvenile fish from repopulating reefs. This has led to the current lionfish invasion being unstoppable. Lionfish feed using a variety of behaviours such as prey stalking, corralling prey in groups, ambushing, and cornering prey with their large pectoral fins. They can also disperse through buoyant eggs and a pelagic larval phase. The above characteristics have enabled lionfish to invade the Atlantic Ocean successfully.

Q2. In general, which characteristics do you think makes an invasive species successful in its new environment?

Ans. Invasive Species have many different characteristics that allow them to be successful; some of these characteristics are their populations' ability to proliferate, having a very general diet, ability to spread out to many different areas, and ability to withstand many environmental conditions. The ability of the species to populate quickly is crucial to their survival. External factors may include a lack of predators, a surplus of prey, a suitable environment for growth and reproduction, etc.

Q3. Copy your $N_{t+1}$ values for each year into the table below. These will be generated when you complete the Click & Learn previous rows

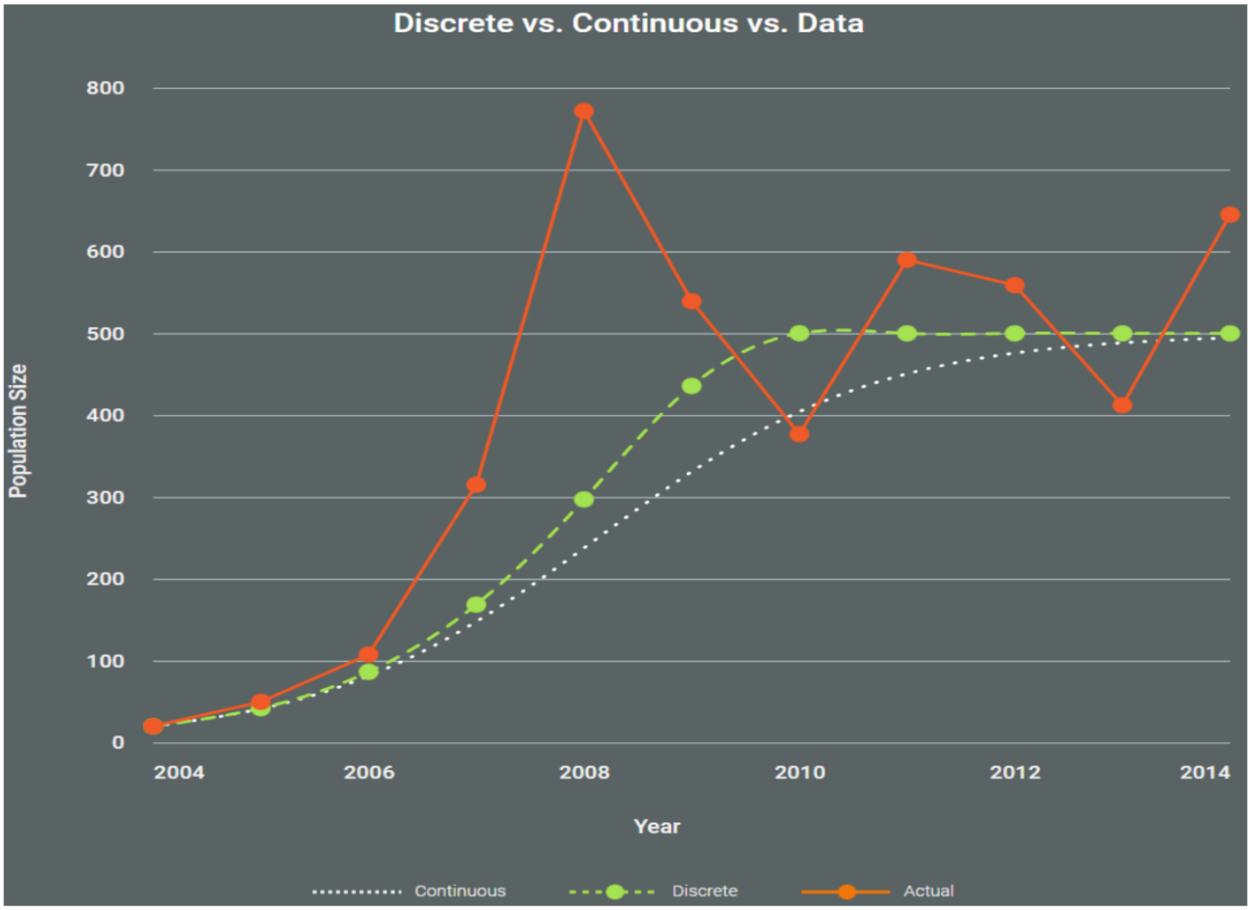
Ans.

| 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| 434.69 | 499.68 | 499.68 | 499.68 | 499.68 | 499.68 |

Q4. Why is the continuous-time model more appropriate for modelling lionfish?

Ans. Physical systems typically evolve more or less smoothly in continuous time, and fundamental models that attempt mechanistic descriptions of these systems generally consist of collections of ordinary differential equations, partial differential equations, integral equations, and so forth. Conversely, computer control is generally implemented at discrete time instants, based on measurements made at discrete time instants. Consequently, computer-based control is commonly based on discrete-time dynamic models, possibly obtained as approximate discretizations of continuous-time models. Also, a point that is particularly relevant to this discussion is that discrete-time models are generally much easier to identify from input–output data than continuous-time models. In the case of simple linear models, an exact correspondence between continuous-time and discrete-time models is possible, but this correspondence does not extend to the nonlinear case.
Discrete-time model of lionfish population growth assumes that any major changes in population size, such as reproduction and death, occur in separate yearly steps. In reality, lionfish reproduce all throughout the year — every four days for some fish! To include these more frequent changes in our model, we can use time periods shorter than one year. If the time periods are so short that changes happen instantly, our discrete-time model turns into a continuous-time model.
Continuous-time models assume that changes happen instantly and describe how a population is changing at any time. They are used to model populations of organisms that reproduce year-round as lionfish do. In these models, the population growth rate is the change in population size ($dN$) over an instantaneous time interval ($dt$), which is written as $\frac{dN}{dt}$.
Thus, the continuous-time model is more appropriate for capturing these frequent changes.

Q5. Compare the three curves shown in the graph below.




a) How does the curve for the continuous-time model compare to the curve for the discrete-time model?

Ans. The curve for the continuous-time model increases less steeply than the curve for the discrete-time model, but both level off at the same carrying capacity by 2014. In the continuous-time model, the population growth rate updates continuously. In this particular discrete-time model, the population growth rate updates only once a year.

b) How do the curves for both models compare to the population estimates based on diver data? What might explain the differences?

<u>Ans</u>. The curves based on the models are much smoother than the data-based estimates. The data-based estimates have much greater year-to-year variation, including a big spike in 2008 and fluctuations around the carrying capacity.
The variations in the data-based estimates could be due to the divers miscounting the fish or the fish not being evenly distributed between the places the divers took samples from and the rest of the areas (sampling errors). These variations could also be caused by real variations in the lionfish population size, which may be due to environmental changes or time lags between when a certain population size is reached and ecological consequences of this new population size (e.g., changes in survival and reproductive ability). The simple models used here do not include these types of errors or variations and therefore appear smoother and more idealized.

# Bibliography


- Corey Eddy, Joanna Pitt, Ken Oliveira, James A. Morris Jr, Jennifer Potts & Diego Bernal "The life history characteristics of invasive lionfish (*Pterois volitans* and *P. miles*) in Bermuda" *Environ Biol Fish* (2019) 102:887–900. Doi: https://doi.org/10.1007/s10641-019-00877-4
- Paul H. Evangelista, Nicholas E. Young, Pamela J. Schofield and Catherine S. Jarnevich "Modeling suitable habitat of invasive red lionfish *Pterois volitans* (Linnaeus, 1758) in North and South America's coastal waters" *Aquatic Invasions* (2016) Volume 11, Issue 3: 313–326. Doi: http://dx.doi.org/10.3391/ai.2016.11.3.09
- "Characteristics of Invasive Species" [Characteristics of Invasive Species | Invasive Species (longwood.edu)]
- National Oceanic and Atmospheric Administration "Invasive Lionfish", [lionfish_factsheet.pdf (noaa.gov)]
- Texas A&M University "How the venomous lionfish invaded the Atlantic Ocean" [How the venomous lionfish invaded the Atlantic Ocean - Futurity]
- Jacques Blum, François-Xavier Le Dimet, I. Michael Navon "Data Assimilation for Geophysical Fluids" *Handbook of Numerical Analysis* Volume 14, 2009, Pages 385-441. Doi: https://doi.org/10.1016/S1570-8659(08)00209-3
- R.K. Pearson "Control Systems, Identification" *Encyclopedia of Physical Science and Technology* (Third Edition) 2003, Pages 687-707. Doi: https://doi.org/10.1016/B0-12-227410-5/00140-X
- Mark M. Meerschaert "Simulation of Dynamic Models" *Mathematical Modeling* (Fourth Edition) 2013, Pages 171-219. Doi: https://doi.org/10.1016/B978-0-12-386912-8.50006-3