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TECHNICAL REPORT

BIFURCATION ANALYSIS OF STAGE-STRUCTURED SEA TURTLES' POPULATION WITH TIME DELAY

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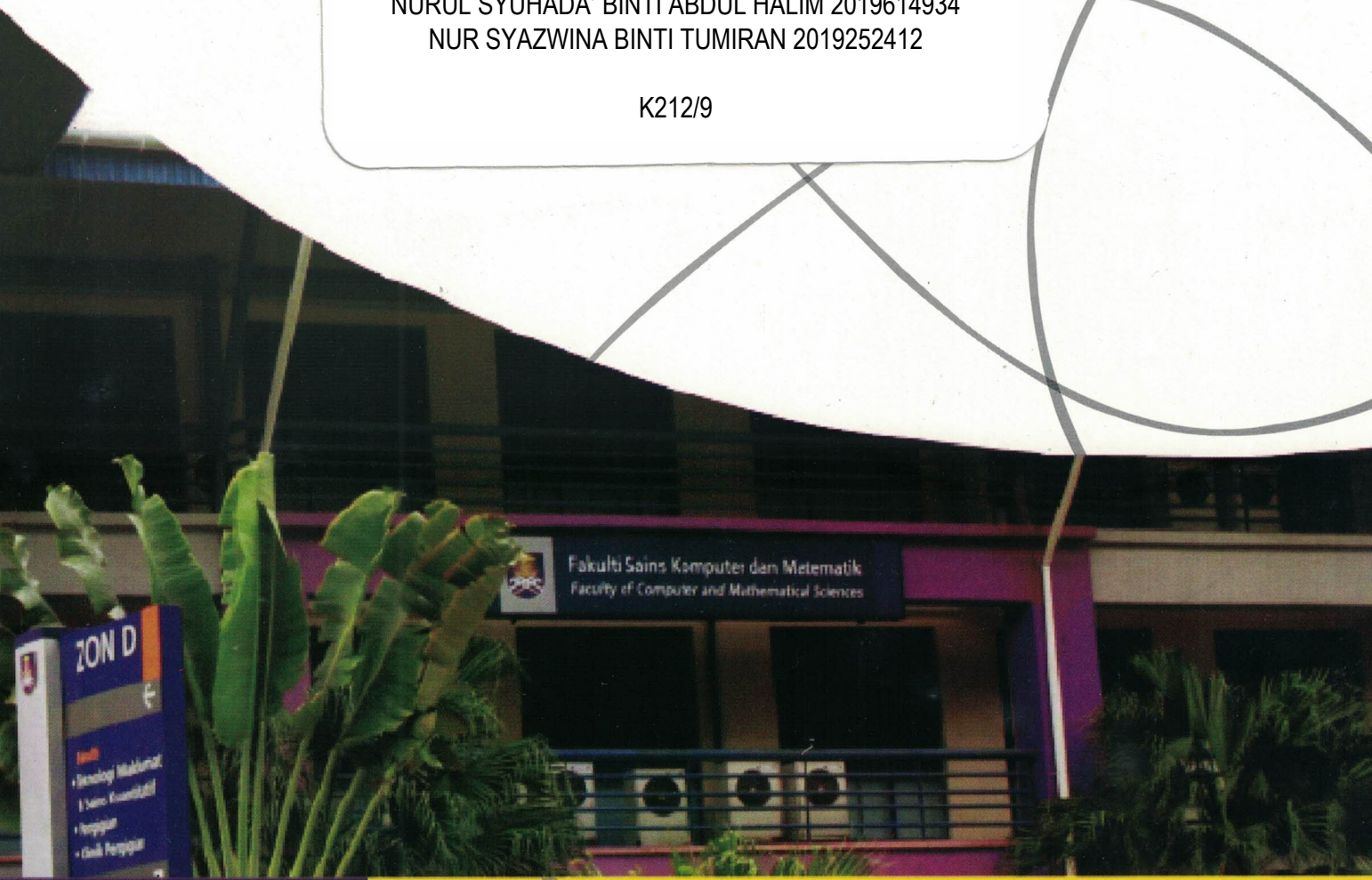

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ABSTRACT

In this paper, we examine the sea turtle population's time-delayed population dynamics. The population of sea turtles in Malaysia is declining, and they are one of the country's endangered species, according to previous research. Additionally, the presence of temporal delay may cause population decline and oscillations in population persistence. So, in order to determine its equilibrium point, we conducted a stability analysis on a population of sea turtles with a delayed stage structure. It is discovered that it is asymptotically stable at the interior equilibrium. A Hopf bifurcation with delay as the bifurcation parameter has been carried out to examine the population's response to time delay. It is discovered that Hopf bifurcation does not take place at the interior equilibrium point, indicating that no stability switch or bifurcation takes place for all delays. Numerical simulations were conducted to study the population's behavior as a result of a time delay in order to corroborate the analytical results. The graph illustrated using MAPLE software support our findings.

1 INTRODUCTION

1.1 Research Background

1.1.1 Stage-Structured Population Model with Time Delay

(A) Stage-Structured

A natural phenomenon known as stage-structured refers to the division of a population into immature and mature individuals Dai et al. (2021). According to Pilcher et al. (2021), sea turtles are migratory animals that travel between foraging and breeding grounds. For most species of sea turtles, hatchlings emerge from their nests, swim into the water, and live in oceanic habitats until they move to coastal feeding grounds many years later.

The difficulty of establishing the ages of people frequently hampers the study of the dynamics of natural biological populations. However, working in terms of a stage structure rather than an age structure might indeed help to solve this problem. Individuals in a population's life cycle may consist of a series of recognizable morphological phases that are entered one after the other till death. The dynamics of such a population may thus be represented by distributions of stage length and temporal survival rates.

Sea turtle populations provide a major area of application of the stage-structured approach to modeling. The lifecycle of a sea turtle is often separated into four stages: egg (nesting), hatchlings, juvenile, and adult (immature and mature). Post-hatchling sea turtles finish their development in the neritic zone until they are early juveniles during their immature stage. Later juvenile and adult development take place in the oceanic zone. It first lay eggs to produce baby turtles by digging holes in sand or mud in a sage nest and burying them. This action protects the eggs against predators. The eggs are then left there from spring to summer to grow and become babies and it takes about three months to hatch.

The hatchling stage of the sea turtle's life cycle is when the baby turtles peck their way out of the eggs and struggle to survive on their own. Baby sea turtles face a very difficult challenge