BREEDING MARINE BIRDS IN THE SOUTHEAST MEDITERRANEAN COASTS OF ANATOLIA: HABITAT-POPULATION SIZE RELATIONSHIP, AND GENETIC STRUCTURE OF THREATENED AUDOUIN'S GULL POPULATION

THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF MARINE SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

BATUHAN ÇAĞRI YAPAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
IN
OCEANOGRAPHY

September, 2018

Approval of the thesis:

BREEDING MARINE BIRDS IN THE SOUTHEAST MEDITERRANEAN COASTS OF ANATOLIA: HABITAT-POPULATION SIZE RELATIONSHIP, AND GENETIC STRUCTURE OF THREATENED AUDOUIN'S GULL POPULATION

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ABSTRACT

BREEDING MARINE BIRDS IN THE SOUTHEAST MEDITERRANEAN COASTS OF ANATOLIA: HABITAT-POPULATION SIZE RELATIONSHIP, AND GENETIC STRUCTURE OF THREATENED AUDOUIN'S GULL POPULATION

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September, 2018, 117 Pages

Presence and distribution of marine bird populations are important indicators of the ecosystem health and the extent of anthropogenic pressures on marine environment. During last century many of the sea bird populations have faced extinction risk due to climate change, exploitation of natural resources, pollution, presence of invasive species and habitat destruction. Although Northeast Mediterranean is considered as an oligotrophic basin; southeast coasts of Anatolia have five historically breeding marine bird species with important marine bird breeding habitats; which hosts species of conservation concern. However, no comprehensive survey on habitat properties of the nesting sites, and no standardized monitoring studies have been conducted to date; which hampers our understanding of regional marine bird ecology and marine ecosystem. In this study, standardized surveys have been conducted on colony size, habitat types, presence of mammals on the entire marine bird breeding sites in the region; in order to evaluate status of the breeding marine bird populations and the effect of habitat quality. In addition to these surveys, we aimed at understanding the connectivity, population structure and history of the most threatened marine bird in the region, Audouin's gull, by using mtDNA D-Loop as a genetic marker. Eight Yellow-legged gull, three European shag and one Audouin's gull breeding colonies were detected during the fieldwork. Results of the habitat-marine bird population interaction analyses suggested a notable effect of vegetation type on nest density mediated by a negative effect of presence of invasive mammals. In addition to that, high anthropogenic pressure on coastal habitats was detected. A pilot study using mtDNA genetic marker revealed extremely low variation in the

D-Loop region of Audouin’s gull, which underlines the importance of using multi-loci methods to better understand population structure and history of gull species. This study fill an important gap of the knowledge on marine birds of Northeast Mediterranean and provide a basis for effective monitoring studies and conservation management of marine birds in the region.

Keywords: Marine Bird, Northeast Mediterranean, Distribution, Bioindicator, Phylogenetics

ÖZ

ANADOLU'NUN GÜNEYDOĞU AKDENIZ KIYILARINDA ÜREYEN DENİZ KUŞLARI: HABITAT-POPÜLASYON BÜYÜKLÜĞÜ İLİŞKİSİ VE NESLİ TEHLİKE ALTINDAKİ ADA MARTISI POPÜLASYONUNUN GENETİK YAPISI

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Eylül 2018, 117 sayfa

Deniz kuşu popülasyonlarının varlığı ve dağılımı, ekosistem sağlığı ve deniz ekosistemi üzerindeki insan baskısının önemli göstergeleridir. Son yüzyıl içerisinde deniz kuşu popülasyonlarının çoğu iklim değişikliği, doğal kaynakların aşırı kullanılması, kirlilik, istilacı türlerin varlığı ve habitat tahribatı gibi sebeplere bağlı olarak yok olma tehlikesiyle karşı karşıya kalmıştır. Kuzeydoğu Akdeniz, aşırı derecede oligotrfik bir havza olarak değerlendirilmesine rağmen Anadolu'nun güneydoğu kıyıları, besin kaynaklarına yakın ve avcı hayvanlara uzak olan elverişli üreme habitatlarına sahiptir. Bölgede beş deniz kuşu türünün ürediği belirlenmiştir. Ancak, bu güne kadar bu türlerin üreme popülasyonları üzerinde kapsamlı ve standardize edilmiş yöntemlerin uygulandığı herhangi bir izleme çalışması yürütülmemiştir. Deniz kuşlarının korunması ve ekosistem üzerindeki insan baskısı ve ekosistem sağlığı için belirteç türler olarak kullanılması için bu tarz çalışmalar büyük önem arz etmektedir. Bu çalışmada, Göksu Deltası ile Gazipaşa arasını kapsayan kıyı şeridinde üreyen deniz kuşu popülasyonlarının durumunu ve bu popülasyonların habitat özellikleriyle ilişkilerini değerlendirmek için koloni büyüklüğü, habitat türleri, bölgedeki üreme alanlarında memelilerin varlığı ile ilgili arazi çalışmaları yapılmıştır. Bu arazi çalışmalarına ek olarak, nesli tehlike altındaki Ada martısının popülasyon yapısı, geçmişi ve diğer popülasyonlarla gen alışverişi durumunun anlaşılması için mitokondriyal DNA D-Loop bölgesi genetik belirteç olarak kullanılmıştır. Yapılan çalışmalarda sekiz Gümüş martı, bir Ada Martısı ve üç

Tepeli karabatak üreme kolonisi kaydedilmiştir. Habitat-deniz kuşu popülasyonu etkileşimi analizlerinin sonuçları, bitki örtüsü tipinin yuva dağılımı üzerinde önemli bir etkisi olduğunu ve istilacı memelilerin varlığının dikkate değer olumsuz etkilerini ortaya koymuştur. Aynı zamanda, habitat üzerinde insan baskısının yüksek olduğu görülmüştür. Ada martısı üzerinde yapılan genetik çalışmada, seçilen belirteçteki polimorfizmin beklenenin çok altında olduğu görülmüştür. Bölgedeki popülasyonların küçüklüğünden dolayı örnek sayısının düşük olmasına rağmen bu çalışma Kuzeydoğu Akdeniz'deki deniz kuşları ile ilgili bilgi eksikliklerini dolduracaktır. Ayrıca, bu çalışmanın bölgede yapılacak olan izleme ve koruma faaliyetlerine temel teşkil etmesi umut edilmektedir

Anahtar Kelimeler: Deniz kuşu, Kuzeydoğu Akdeniz, Yayılış, Biyoindikatörler, Filogenetik.

To Dolphins,
I hope they will not leave the Earth soon.

ACKNOWLEDGMENTS

This study is a very small step for Humankind, maybe a bigger step for marine birds of Northeast Mediterranean, but surely a giant leap for me. I would like to thank many people; of course it would not be possible complete such a work without their help.

I sincerely thank my supervisor Dr. Korhan Özkan for all the things he taught me on ecology, study design, observation, data collection and analysis. In addition to those he is a great teacher who helped me to learn how to do science in such a complex and tough world. Also, he has encouraged me in daily challenges of world of science. And let me learn things not only in scope of this study, but more.

I would like to thank my thesis committee members, Dr. Arzu Karahan and Dr. Utku Perktaş for their valuable criticism on the thesis, also for their help in laboratory work and analysis.

This study is mainly supported by METU BAP-08-11-2015-027 project, Survey on Effects of Anthropogenic Pressure on Bird Communities; it is also partially supported by DEKOSIM Project. I would like to thank all supporters and participants of those projects.

I would like to thank crew of R/V Bilim 2 and R/V Lamas for welcoming me aboard, and providing suitable and safe environment for conducting survey at sea.

I am grateful to Can Elverici from Hacettepe Biogeography Research Laboratory for his help to understand how to deal with bird samples. Also, Neşe Güvençli and Işılay Çelik have helped me in laboratory with their skilled hands.

I would like to thank my old friends Melis, Hüsnü and Ekim for not leaving me in an isolated pirate haven, and keeping in touch.

I would like to thank my friends and colleagues here in METU IMS; Emel, Gizem, Onur, Merve, Kerem, Dilara for supporting me and helping me to stay sane, and stand with me when I could not manage to do so.

Without inspiring masterpieces of Henry David Thoreau, Yaşar Kemal, Orhan Veli Kanık, Kurt Vonnegut and Douglas Adams it might be much harder to keep going, find reason and a way. I also would like to thank them.

My family is the main contributor of this project. If my mother and father have not let me go out and enjoy discovering, and have not fed my curiosity with many more questions and books; I would not be in the beginning of this long, challenging and beautiful track.

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1- INTRODUCTION

1.1 Marine Birds

Marine birds are group of birds which live and feed on sea and coastal habitats. Although that group involves several orders of birds which have different phylogeny, behavior and life history traits; they have similar adaptations those are selected for their advantage on offshore and coastal niches (Schreiber & Burger, 2001). Globally, there are 346 species that are identified as marine bird (Croxall *et al.*, 2012). Most of the species in orders Sphenisciformes, Procellariiformes, Pelecaniformes, Charadriiformes are defined as marine birds (Schreiber & Burger, 2001). However, recent phylogenetic studies suggest another phylogenetic relationship which places Pelecaniformes (involving pelicans), Suliformes (involving gannets, frigate birds, cormorants); and Phaethontiformes (includes tropic marine birds) on different branches of evolutionary tree (Hackett *et al.*, 2008), while taxonomists previously have suggested these three orders in one order Pelecaniformes due to their physiological and behavioral similarities (Schreiber & Burger, 2001) .

Marine birds are consumers that feed on different trophic levels of marine food web (Shealer, 2001). Involving mostly small pelagic fish, crustaceans and mollusks (Montevecchi, 1993) the diet of marine birds is vast; ranging from zooplankton to remnant of large species. Marine birds have physiological and behavioral adaptations according to their main food source. Gulls and terns are foraging on coastal areas where their prey are abundant or forced to be close to surface; diving marine birds such as penguins could dive deeper and spend more time while catching fish. Pelagic birds like albatrosses and petrels could soar on water for long distances to find dispersed food sources; their specialized wing properties provides low energy cost during those long flights (Shealer, 2001). Foraging as flocks is a common behavior for marine bird species. Although flock forming and feeding on patches looks like a random process which occurs by seeing other foraging birds and joining them; tracking studies have revealed that marine birds generally have fidelity for specific feeding areas which they have food efficiently (Irons, 1998). Flock feeding might also help young birds how to chase and catch

prey. Success in breeding attempts, and efficiency of marine birds increase with experience (Greig *et al.*, 1983).

Marine birds are considered as long living species. Sexual maturation of most of them take years and annual productive rate is generally low (Schreiber & Burger, 2001). First breeding age of most of the marine bird species is 2 or 4-5; even later for some species. That relatively long time is suggested to be spent to acquire skills for foraging and raising chicks (Weimerskirch, 2001). Most of the marine bird species breed on an annual cycle, but some species such as King Penguin (*Aptenodytes patagonicus*) has a complete breeding cycle more than 400 days (Hamer *et al.*, 2001); while some, such as sooty terns (*Onychoprion fuscatus*) inhabiting tropical regions breed more than once in a year (Reynolds *et al.*, 2014). Breeding cycle of marine birds is affected by several factors; weather, food availability, age and experience are the most important of them (Hamer *et al.*, 2001). Breeding success and frequency of marine birds mainly depend on condition of the sea and availability of food; for example, long term monitoring studies revealed that El Nino Southern Oscillation effects breeding success of Blue-footed boobies. The study shows that increase in water temperature during ENSO events directly decrease clutch size and survival of the chicks; reason of this decline in breeding success could be explained by decreasing production due to warming (Ancona *et al.*, 2011). Breeding phenology of marine birds have also been changing with global climate change, but change rate of marine birds' phenology could not match the rate of climate change, result in a mismatch with peak of food abundance. This situation might create a global threat for marine birds by affecting breeding success of birds negatively (Gaston *et al.*, 2009).

Marine birds could be divided into three major groups according to their breeding habitats. Marine birds feeding from pelagic waters such as albatrosses breed on oceanic islands. Coastal feeders such as gulls and cormorants prefer breeding on cliffs or on islands close to mainland. Some marine birds may choose inland and coastal wetlands to breed (Hamer *et al.*, 2001), Mediterranean gull is a characteristic example of those species (BirdLife International, 2016). Nesting habitats and nest types of the marine bird species are affected by interaction with other bird species, topography and vegetation features of the breeding habitat (Fasola & Canova, 1991). Marine birds could form single species colonies or several species could breed on the same site. If a breeding habitat such as an islet is suitable for more than one species,

some species might expel others by competitive advantage of their size. For example, Yellow legged gulls decrease breeding success of Audouin's gull by expelling the species from breeding sites (Paracuellos & Nevado, 2010). Place and types of the nests differ between species; while most of the gulls nest on open ground; species like Cory's shearwater (*Calonectris borealis*) breeds in burrow type nests (Oppel *et al.*, 2014). Colonial breeding is another feature of the most of the marine bird species. Although there are disadvantages such as competition for the nesting space, risk of epidemic disease, infanticide; marine birds prefer nesting closely even if there are other suitable places to breed. Reason of that unexpectedly common colonial breeding behavior could be the advantage against predators. In addition to that, colonies could act as information centers from which birds could learn about location of food patches (Buckley, 1997)

Population size and structure of marine birds are dependent on their interaction with the environment in which they live. Adaptation to environment and effect of life history traits on selection directly affects demography of the population. Euler-Lotka equation, whose parameters are sexual maturity, age of last reproduction, survival rate and fecundity reveals status of population and relationship of those parameters with growth rate (Wimerskirch, 2001). Life history strategies of marine birds evolved according to their size, flight ability and foraging style. Marine birds with energy efficient flight, big size such as albatrosses tend to have longer lifespan, and mortality of adults are low; however, marine birds with energy consuming flight styles such as cormorants have shorter life span, and adult mortality is higher in these species. Fecundity of the latter group is higher, but mortality ratio of chicks and their parents strictly dependent on availability of food (Oro *et al.*, 1999) and weather conditions (Thyen & Becker, 2010). Life history features and survival strategies of sea bird species could only be learned by long term monitoring; knowledge on those has vital importance on selecting right species or group of marine birds for assessment of different properties of marine ecosystems (Parsons *et al.*, 2008).

1.2 Threats on marine birds

Marine bird populations face severe threats all over the world (Croxall *et al.*, 2012). A metadata analysis revealed that 69% of monitored sea bird populations around the world have been lost between 1950 and 2010 (Paleczny *et al.*, 2015).

Climate change (Wormworth & Şekercioğlu, 2011), loss of breeding habitats due to human activities (Dolman & Sutherland, 1994), presence of invasive species (Travaset *et al.*, 2009), overexploitation of food sources (Monaghan, 1992), bycatch (Tasker *et al.*, 2000), plastic pollution (Wilcox *et al.*, 2015), accumulation of hazardous metals and chemicals (Walsh, 1990) are leading causes of this drastic decline; and the situation gets worse by combination of all this threats.

Previously mentioned above, marine bird fecundity and breeding success directly dependent on weather conditions and availability of food. Change in weather conditions, sea temperature, precipitation regime affect production in marine ecosystems. While organisms at lower trophic levels are adapted easier to changes in environment; higher trophic level organisms have lower capacity to adapt to changing climate conditions and therefore are more vulnerable (Thackeray *et al.*, 2016). Most of the marine bird species are not an exception of this situation; due to high turnover time and life history features of marine birds, phenological variation in their breeding time is low; advance or delay level in breeding time of the species is low, and nesting time is not correlated with sea surface temperature especially for larger species and species distributed at high latitudes (Keogan *et al.*, 2018). Low adaptation rate to changing climate conditions might affect marine bird populations severely as the time of production peak of lower trophic level organisms is changing faster than marine bird species, that cause trophic mismatch and decrease in energy transmitted across each level. Marine birds are at the top and the most affected group; this situation might cause decrease in breeding success and survival rate of adults in future (Burthe *et al.*, 2012). Increase in intensity and frequency of extreme weather events is another result of global climate change (Fischer & Knutti, 2015). Eggs and chicks are vulnerable to extreme atmospheric events such as snow storms (Descamps *et al.*, 2015), high rainfall and flood (Thompson & Furness, 1991); these extreme events decrease hatching rate of Antarctic petrels and Manx shearwater respectively. Extreme heat events could also affect breeding success of marine birds via increasing population size of parasites; for example, marine birds, especially chicks are vulnerable to the effects of mosquitoes. A decrease in Arctic inhabitant Brünnich's guillemot breeding success and increase in adult mortality due to mosquitoes have been reported (Gaston *et al.*, 2000).

Habitat loss and decline in breeding habitat quality due to human activities such as urbanization, recreation, transportation is another major threat for bird populations (Owens & Bennett, 2000). Main properties of a suitable breeding site for marine bird colonies are being in good proximity to foraging areas and being away from predators (Hamer *et al.*, 2001); microclimate factors such as exposure to sun and wind also important in nest site selection. Number of suitable nesting sites which provide combination of these features are restricted in marine and coastal environment; and thus both intra and inter species competition for nesting sites are high in marine birds (Oro *et al.*, 2009). Loss of colonies and extinction of species on islands due to human settlement on islands and deterioration of habitat quality have been reported in Mediterranean region (Oro, 2003).

Another major threat to marine bird populations is invasive species on breeding sites, especially on islands. While humans were forming settlements on remote islands they have brought rats and mice with them. Those species became invasive on most of those islands and cause extinction of native species (Towns *et al.*, 2006). Direct predation of eggs and chicks is one of the leading reason of decline in marine bird populations caused by invasive species. Marine birds constitutes up to 24% of diet of invasive rats (Caut *et al.*, 2008). Rats and predation are not the only threats marine birds encounter, invasive rodent species such as rabbits are also affect marine bird populations negatively via indirect effects. Invasive species could change biomass and energy flow, could alter habitats by intense grazing and act as ecosystem engineers (Crooks, 2002). Most of the island ecosystems are vulnerable against invasive species; invasive species could cause change in habitat types of islands (Reaser *et al.*, 2007). Loss of appropriate breeding grounds due to destruction of vegetation by overgrazing, or competition for suitable burrows have negatively affected breeding marine bird populations on California Channel and Baja California Islands (McChesney & Treshy, 1998). Most of the Islands in Mediterranean Sea are occupied by invasive rat species; negative effects of those rats observed on breeding colonies, especially on Procellariiformes, but marine birds in the region have high level of resilience as the extinction rate is low (Ruffino *et al.*, 2009). Geographic characteristics of islands such as size and distance to land or to other islands might create refuges for marine birds (Ruffino *et al.*, 2009).

Destruction of coastal marine habitats is another threat to marine bird species. Coastal regions host productive and important ecosystems, such as estuaries, lagoons and seagrass, with high biodiversity (Costanza *et al.*, 1997). These vulnerable ecosystems are nurseries for many fish species and level of human pressure could be quantified by monitoring fish abundance (Vasconcelos, 2007). Marine bird productivity has a nonlinear relationship with the abundance of foraging fish species, when a threshold is passed breeding success of marine birds decline dramatically (Cury *et al.*, 2011). Another study conducted in Baltic Sea revealed that spatial distribution of marine bird species who has different foraging styles have a strict relationship with fish abundance and distribution (Hentati-Sundberg *et al.*, 2017); observation of foraging marine bird flocks and developing models from these relationships could be used in order to assess health and productivity of coastal ecosystems.

Fisheries is another threat to marine bird species. Prey of fisheries and marine birds are similar; this situation created a competition for sources. In addition to that , overexploitation of fish from lower trophic levels for aquaculture purposes also disrupts energy flow to upper levels (Coll *et al.*, 2008). Combination of these effects cause decline in marine bird populations. Sandeel and sprat are small fish which are important food sources for both carnivorous fish and some marine bird species such as puffins in Arctic Region. Exploitation of sandeel and sprat in North Sea has a dramatic effect on breeding success of marine birds like Arctic terns which directly feed on sandeel (Tasker *et al.*, 2000). Overfishing on sardines cause a shift in Benguela Current fish community, jelly fishes become dominant this situation cause loss of main prey fish for marine birds and reduce their reproductive success (Wagner & Boersma, 2011).

Death due to bycatch in fishing activities has a direct negative effect on marine bird populations (Tasker *et al.*, 2000). Longline fishing is one of the most commonly used fishing techniques. Many hooks with baits in this method constitute a great danger for marine birds; risk of getting caught by a hook is very high for pelagic feeders like albatrosses. Number of albatrosses killed due to bycatch by Japanese fleet in Southern Ocean was estimated at least 44000 annually (Brothers, 1991). Monitoring studies conducted on Western Mediterranean revealed that seven marine bird species are affected by longline fishing activities. Cory’s shearwater

(*Calonectris diomedea*) and yellow-legged gull (*Larus michahellis*) have the highest ratio in caught marine bird species (Barcelona *et al.*, 2010); bycatch might be one of the main driver of declining population trend of that pelagic feeder species. Gillnets are another cause of death of marine bird individuals by entanglement and drowning, especially nets set near the surface are causing decline in marine bird populations, even extinction. More than 500000 individuals are dying due to bycatch in gillnets annually; pursuit divers like cormorants are more prone to be caught by nets (Žydelis *et al.*, 2013). Trawlers also cause of death by drowning (Sullivan *et al.*, 2006). However, discards from trawlers are an important food sources especially for scavenger species (Oro & Ruiz, 1997), due to that high number of marine birds are following fisher boats number of entanglement and drowning incidents are frequent. Those incidents could be prevented by development and changes in fisheries techniques (Bull, 2007)

Plastic pollution has become one of the biggest threats to ecosystem; millions of tones of plastic products are produced every year, and a considerable part of them ends up in oceans (Derraik, 2002). Latest studies shows that up to 35000 tones of plastic debris is floating on surface waters of open ocean, especially on subtropical gyres (Cozar *et al.*, 2014), amount of plastic is also high on coastal regions where human population is high (Vince & Hardesty, 2017). Plastics have several way of negative effects on organisms and ecosystems such as entanglement, smothering, transferring invasive species (Gregory, 2009), microplastics are vector for heavy metals (Brennecke *et al.*, 2016) and other toxins (Tanaka *et al.*, 2013). It is known for long time that marine birds are prone to ingest plastic debris; a meta analysis done by Wilcox and colleagues has revealed that 80 of 135 marine bird species studied had been reported to ingest plastic between 1962 and 2012 (Wilcox *et al.*, 2015); same study reveals that plastic ingestion incidents are increasing due to accumulation of plastics in the ocean, and models predict that 99% of the marine bird species will ingest plastic by the 2050 (Wilcox *et al.*, 2015). Plastics are strong polymers whose digestion is nearly impossible and retention time in stomach is long (Ryan, 1987). Although ingestion of plastic is common in marine bird species (Wilcox, 2015), retention time in the gut changes according regurgitation behavior of the species; while gull species throwing up undigested food usually, this behavior is rare in some petrel species, plastic debris is accumulating in second part of the stomach, grizzard (Ryan & Jackson, 1987). Studies focused on fulmarine petrel species breeding in

Antarctica revealed that plastic debris content in digestive track changes spatially. While plastic particle content is high in chicks of migratory petrel species, amount of plastic in non-migratory petrel species is too low; this difference could be explained by low plastic pollution in the region on the date of study, migratory petrels were carrying the plastic they ingested in wintering regions (Van Franeker & Bell, 1988). Also, long term monitoring studies on fulmars revealed that types and amount of plastic ingested by those birds is a good indicator of type of debris in sea, amount and distribution of it (Van Franeker & Lavender, 2015). Negative effects of plastic ingestion on marine birds could be divided into three groups: damage to digestive track (Ryan, 1987), decrease in foraging efficiency (Drever *et al.*, 2018), and release of toxins to body (Tanaka *et al.*, 2013).

Heavy metal pollution and chemical pollution are other major threats for marine bird species. Due to their higher trophic level in marine food web; accumulation level of heavy metals is high in marine birds, especially in feathers and eggshells (Walsh, 1990). Level of increase of those contaminants could be followed by comparison of museum specimens with modern populations (Furness & Camphuysen, 1997). Food source of the species and gender of individual has importance in the accumulation level of the metals (Hutton, 1981). Although effect of contamination level in the region from which species ranging is important (Hutton, 1981); a study conducted on *Larus audouinii* colonies breeding on Aegean Islands has reported annual fluctuations in the samples from the same colony region, and not a significant difference between more contaminated regions and normal regions (Goutner *et al.*, 2000). Marine birds are also important indicators of organochlorines and other organic pollutants. A review study on which DDT levels in tissues of marine birds and waterbirds clearly demonstrates indicator role of marine birds in monitoring of presence of DDT and its metabolite DDE (Ayaş, 2007).

Marine birds are also affected negatively by oil spills on sea, their high range for foraging activity make them sentinels of oil spills on remote areas. Hydrocarbons stick on feathers of marine birds, and might have lethal effects on birds; and depending on severity of the incident high number of birds could be affected. For example, due to oil spill from the tanker Prestige in Iberian Coasts 22981 contaminated marine birds have been recorded (Munilla *et al.*, 2011). Taking record of location, species composition and number dead individuals is a way of assessment

of magnitude of incident; evaluation of this results with exposure probability models would improve reliability of the assessment (Haney *et al.*, 2017).

1.3 North East Mediterranean Sea

Mediterranean Sea is an almost enclosed sea; due to low river input and restricted upwelling, nutrient content of the sea is low. It has been defined as an oligotrophic sea, phosphorus limited (Krom *et al.*, 1991), low-nutrient low-chlorophyll system (Guo *et al.*, 2016). Main river inputs to the sea are Rhone, Po and Ebro Rivers; nutrient brought by those rivers have a seasonal and local effect, increase primary production on north-western coastal regions in fall and winter (Azov, 1991). There is a decrease in primary productivity from western basin towards to east (Moutin & Raimbault, 2002). Eastern basin of the Mediterranean Sea has ultra-oligotrophic conditions, so that it has been described as a marine desert (Azov, 1991). Productivity of the Eastern Mediterranean has been reported as lower than other oligotrophic areas as Sargosso Sea and Arabian Sea (Pitta *et al.*, 2005). Ceyhan, Seyhan, Berdan, Lamas and Göksu Rivers, aerosols and dust from atmosphere are important nutrient inputs to North East Mediterranean basin. While river inputs are the main source of silicate by a ratio of more than 90%; atmospheric input is main source for nitrogen and phosphorus by 90% and 60% respectively (Koçak *et al.*, 2010); DIN content in those inputs, especially in atmospheric source, is extremely high against Phosphorus content, this situation is exacerbating phosphorus deficiency (Koçak *et al.*, 2010). This nutrient deficiency brings consequence of lower primary productivity. Chlorophyll-a concentration of eastern Mediterranean basin is c. 125 ng/l, deep chlorophyll maximum is around 250 ng/l at 90-110 m depth (Yacobi *et al.*, 1995). In addition this low level of primary production, a high proportion of energy and material produced is flowing through bacterial heterotrophs. This cause low level of vertical transport of energy in food web which means low amount of fish mass in the region (Turley *et al.*, 2000). Marine bird abundance, survival and fecundity are related with food availability (Cairns, 1987), so low number of marine birds are expected in Eastern Mediterranean compared to other seas.

Suitable nest sites isolated from terrestrial predators is another factor that affects presence and abundance of marine birds especially in breeding season. Taurus Mountains are close to the sea especially between Alanya and Taşucu districts. That creates the highest cliffs on Southeast Mediterranean coastline of Anatolia (Doğaner, 2017). Those cliffs are suitable nesting sites for European shag (*Phalacrocorax aristotelis*) (BirdLife International, 2016b). Position of the mountains results in a limited number of island and islets (Doğaner, 2017). Coastline between Alanya and Taşucu comprises the only islands and islets in all Eastern Mediterranean region with Cyprus and small islands in its vicinity. There is vegetation on some of the islands; those islands are potential breeding sites for gull and tern species. Despite their importance for breeding bird species in the region there was not a comprehensive survey on those islands before our study. Distance between mountains and sea increase at east of Taşucu, and coastline with alluvial deposits started; Göksu Delta and Çukurova Delta are the most important structures on the coastline (Doğaner, 2017). Göksu Delta is an important area for birds; it provides rich food source and nesting grounds, 332 bird species are recorded in this Important Bird Area; 70 of them are breeding, 20 are suspected to breed (Yaran & Magnin, 1997). Göksu Delta is an important area for wintering marine bird species; lagoons in the delta are highly productive; Mediterranean gull (*Larus melanocephalus*), Little gull (*Larus minutus*), Black-headed gull (*Larus ridibundus*) are some of those species. There are many areas isolated from human disturbance which provides ground for resting (Yaran & Magnin, 1997). Five major rivers are causing alluvial deposition in the region, flat coastline continues by widening until Amanos Mountains (Doğaner, 2017). Yumurtalık and Karataş Lagoons are other important areas for marine bird species. Coastline gets closer and higher in Eastern part of the region due to geomorphology of Amanos Mountains (Doğaner, 2017), but there is no island or islets in this part of the region.

Climate of Mersin Province could represent climate of the region. Annual average temperature of Mersin is 19.2 ºC, average of annual precipitation is 592.1 mm, August is the warmest and driest month with 28.3 ºC average temperature and 5.1 mm rainfall; most of the rainfall drops in winter season (TCMGM, 2018). When climate indicators between 1981 and 2010 is considered, climate of the region is classified in Hot Summer Mediterranean Climate (Csa) in Köppen Geiger Climate Classification, whose features is hot and dry summers, coldest temperature and high

precipitation in winters (Kottek *et al.*, 2006). Climate projections predict robust warming, high interannual variability and increase in frequency of extreme heat events in Mediterranean Region, and according to the study effects of global climate change will effect the region more intensely than global climate (Giorgi & Lionello, 2008).

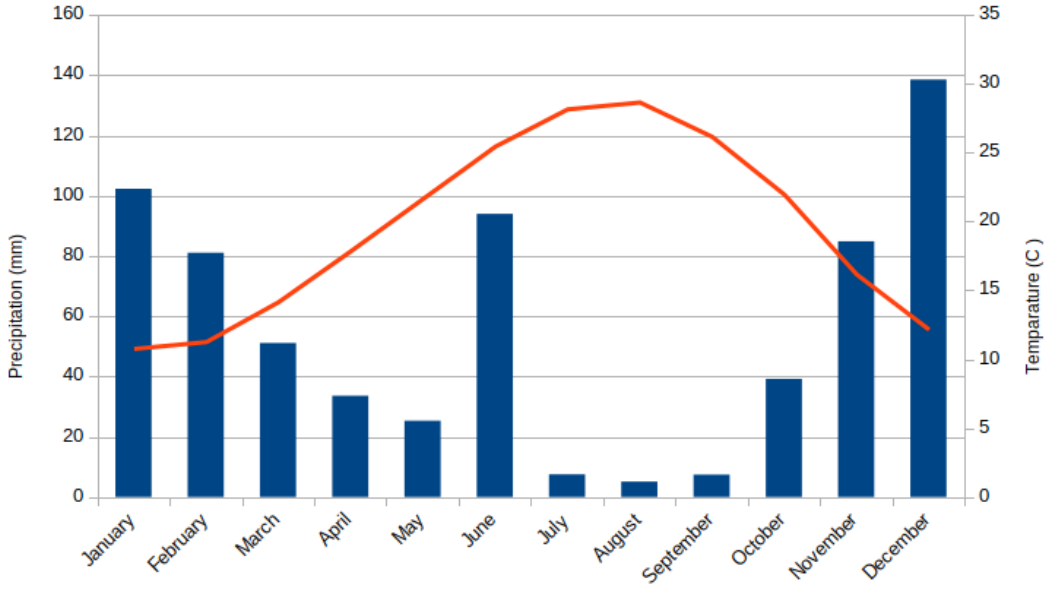

Figure 1 Precipitation (blue bars) and temparature (red line) trends of Mersin Region. Graph is produced from climate data. (TCMGM, 2018)

1.4 Marine Birds of Northeast Mediterranean Region

Thirty nine marine bird species have been recorded in Mediterranean coasts of Turkey (Güçlüsoy *et al.*, 2014). According to birdwatching records for the region between Hatay and Antalya 28 marine bird species are observed in Eastern Mediterranean coasts of Anatolia (eBird, 2012). Five of those species, Yellow-legged gull (BirdLife International, 2017), Audouin's gull (Çağlayan, 2003), European shag (BirdLife International, 2016b), Common tern (BirdLife International, 2016c), Little tern (Magnin&Yarar, 1997) have certainly bred (Table 1) in the region.

Table 1 Marine bird species observed between Hatay and Alanya. Table was formed by using bird observation records from 1968 to 2017 present in eBird. Status column indicates IUCN Red List status of species, global trend information is also taken from IUCN. Breeding column is formed by using eBird data, Magnin & Yarar's report in 1997, and observations done by our group. "yes" indicates direct observation of nests and/or juveniles, "probable" indicates species are observed in region during breeding period, but no claim of nests or juveniles.

Common name	**Latin**	**Status**	**Global Trend**	**Breed**	**Last Seen**
Yellow-legged Gull	*Larus michahellis*	LC	increase	Yes	2017
Audouin's Gull	*Larus audouinii*	LC	stable	Yes	2017
Lesser Black-backed Gull	*Larus fuscus*	LC	increase	No	2017
Yelkouan Shearwater	*Puffinus yelkouan*	VU	decrease	No	2017
Scopoli's Shearwater	*Calonectris diomedea*	LC	decrease	probable	2017
Great cormorant	*Phalacrocorax carbo*	LC	increase	probable	2017
Arctic Jaeger	*Stercorarius parasiticus*	LC	stable	no	2017
Armenian Gull	*Larus armenicus*	NT	decrease	no	2017
Gannet	*Morus bassanus*	LC	increase	no	2017
Black-headed Gull	*Larus ridibundus*	LC	unknown	no	2017
Pygmy Cormorant	*Microcarbo pygmaeus*	LC	increase	no	2017
Caspian Tern	*Hydroprogne caspia*	LC	increase	no	2017
Slender-billed Gull	*Larus genei*	LC	unknown	no	2017
Mediterranean Gull	*Larus melanocephalus*	LC	decrease	no	2017
Gull-billed Tern	*Gelochelidon nilotica*	LC	decrease	no	2017
Caspian Gull	*Larus cachinnans*	LC	increase	no	2017
Black-legged Kittiwake	*Rissa tridactyla*	LC	decrease	no	2017
Mew Gull	*Larus canus*	LC	unknown	no	2017
Pallas's Gull	*Larus ichthyaetus*	LC	increase	no	2017
European Shag	*Phalacrocorax aristotelis*	LC	decrease	yes	2017
Pomarine Jeager	*Stercorarius pomarinus*	LC	stable	no	2017
Long-tailed Jeager	*Stercorarius longicaudus*	LC	stable	no	2016
Little Tern	*Sternula albifrons*	LC	decrease	yes	2015
Black Tern	*Chlidonias niger*	LC	decrease	no	2015
White-winged Tern	*Chlidonias leucopterus*	LC	stable	no	2015
Whiskered Tern	*Chlidonias hybrid*	LC	stable	no	2015
Little Gull	*Hydrocoloeus minutus*	LC	increase	no	2013
Common Tern	*Sterna hirundo*	LC	unknown	yes	2017

Yellow-legged gull (*Larus michahellis*) occupies a wide range consists of coasts and inner regions of Europe, Middle East and North Africa (BirdLife International, 2017). Breeding area of the species involves coasts of Mediterranean, Black Sea, Caspian Sea, Azores and Canary Islands (BirdLife International, 2017). IUCN Red List status of the species is declared as Least Concern, due to extremely large range of the species and increasing population trend (BirdLife International, 2017). Yellow-legged gulls could use many types of habitats as nesting sites such as coastal cliffs, rocky and sandy offshore islands, reedbeds, river islands, pastures, even rooftops at big cities (Soldatini *et al.*, 2008). The species build their nests under or close to shrubs and rocks, protection of chicks from direct sun light is an important factor. Yellow-legged gull is the one of the most abundant marine bird in the study region, population size around Göksu Delta is estimated to be around 600-700 all year long (Ganzeveles, 2013).

European shag (*Phalacrocorax aristotelis*) also has a wide range of distribution. The species is present on Mediterranean, Black Sea coasts; Atlantic coasts of North Africa and Europe; breeding populations exist at all those regions (BirdLife International, 2016b). There is genetic structure between North Atlantic, Spanish-Corsican and Eastern Mediterranean populations of this species caused by a combination of historical, physical and ecological barriers (Thanou *et al.*, 2017). IUCN Red List status of the species is Least Concern, this status is justified by large range of the species (BirdLife International, 2016b). European shags construct their nests on rocks at cliffs, or they prefer caves on rocks; nests could be at sea level or as high as 100 m (BirdLife International, 2016b). One individual of the species was observed at Göksu Delta in spring of 2010 (Ganzevles, 2013), nests and juveniles are observed along Mersin coasts (eBird, 2012).

Common tern (*Sterna hirundo*) is present at inner regions and coasts of Asia, Anatolia, Australia, North of America, coasts of Africa and some parts of Europe. Breeding populations are distributed in all this range (BirdlLife International, 2016c). IUCN Red List Status of the species is Least Concern, the status is justified by very large range, and population trend far from being severely decreasing (BirdLife International, 2016c). Common terns' breeding habitat types could be flat rocks on islands, islands in lagoons and estuaries, vegetated dunes, sandy beaches and more (BirdLife International, 2016c); coasts of North East Mediterranean, especially

Göksu Delta provide such features. Breeding of the species on Göksu Delta is confirmed in 2013, size of the breeding colony was estimated to be 20 individuals (Ganzeveles, 2013).

Little tern's (*Sternula albifrons*) distribution is narrower compared to common tern, the species is recorded on coasts and inner regions of Africa, coasts of Australia and South Asia, inner regions of Asia, coasts and inner regions of Europe, coasts and inner regions of Anatolia (BirdLife International, 2016d). IUCN Red List Status of the species is Least Concern, the status is justified by very large range, and population trend far from being severely decreasing (BirdLife International, 2016d). Nests of the species could be found on ground with a vegetation cover less than 15%, beaches of pebble is another suitable habitat, or species could build nests on salt marshes (Birdlife International, 2016d). Göksu Delta is a suitable breeding area for the species, 150 pairs were reported to breed in the area (Magnin & Yarar, 1997).

Audouin's gull (*Larus audouinii*) is the rarest breeding marine bird of the region. It is a medium sized gull species with weight between 580-770 g (Schreiber & Burger, 2001b), length between 44-52 cm and wingspan of 117-128 cm. Species has four age groups, which means moult and appearance of the individuals change from the first year to fourth color of rump becomes lighter gray year by year until fourth year (Figure 2c, 2d). Adult Audouin's gull could be identified by their short, dark red beak with a black tip, elongated forehead with feathering expanding through nostrils, silver-gray rump, narrow white tail, gray-green legs (Svensson *et al.*, 2009). The species has narrow wings; flight of the species is elegant, gliding occurs frequently. Eggs of the species are light green-olive colored with freckles on it (Figure 2a).

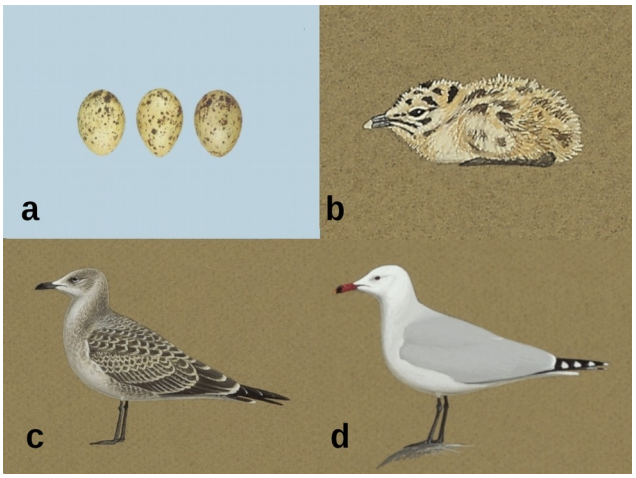

Figure 2 Representative drawings of egg (a), chick (b), juvenile (c) and adult (d) forms of *L.audouinii*. Figures have been retrieved and modified from Snow and Perrins, 1998

Audouin's gull was defined as a nocturnal specialist forager whose target is clupeoids (Oro *et al.*, 1999); however, the species shows plasticity to changes in environment and food sources. Especially in western Mediterranean, chasing and exploiting discard from trawlers is common (Oro & Ruiz, 1997); young individuals of Ebro Delta Population also forage at the delta for invasive American crayfish (Navarro *et al.*, 2010). Average foraging range of Ebro Delta population of Audouin's gull is around 80 km which includes both the delta area and the sea in breeding season (Christel *et al.*, 2012); terrestrial or marine foraging behavior and time of foraging activity depend on environmental conditions and mostly affected by fisheries activity (Becares *et al.*, 2015). As foraging behavior studies show, fisheries activities in west Mediterranean has a great importance on food ability, health and size of the population. When fishing moratorium coincides with chick rearing period, population growth rate decrease, extinction rate of the population increases; also ratio of emigration of juveniles increase to the highest level (Oro *et al.*, 2004). Impact of lack of discards is less dramatic on older adults (Oro *et al.*, 2004), which corroborates with increasing foraging ability with age (Weimerskirch, 2001). Audouin's gull is a monogamous species; forms single-species breeding colonies (Oro *et al.*, 1999). The northwestern populations of the species lay eggs from end of the April to end of June (BirdLife International, 2017b), average clutch size of the species is three (Oro *et al.*, 1999), incubation period is between 26 and 33 days (Schreiber & Burger, 2001b). Chicks are born as semi-precocial (Figure 2b), and fledgling takes 35-40 days (Schreiber & Burger, 2001b). Parents continue to take care of chicks for up to 75 days post fledgling (Schreiber & Burger, 2001b). Main feature of the Audouin's gull

nesting site is isolation from terrestrial predators. Nests were recorded in a wide range of habitats from bare rock to 85% shrub closeness (BirdLife International, 2017b). Medium vegetation cover is preferred, it could be explained by protection of chick from intense sun light and heat (BirdLife International, 2017b). Nests are built on open ground (Schreiber & Burger, 2001b), so flat areas are preferred more. Audouin's gull is a dispersive and partially migratory species (Oro & Martinez, 1994). Migratory behavior of the Ebro Delta population is well observed; by the beginning of autumn most of the birds leave the delta and migrate to Atlantic coasts of North Africa, c. 90 birds remained on the delta for wintering, that number could reach to c.300 for maximum in some years (Guiterrez & Guinart, 2008). Most of the juveniles spend their first year in African Coasts far from the colony they were born (Guiterrez & Guinart, 2008).

Audouin's gull is endemic of Mediterranean basin. Although wintering populations observed on Atlantic coasts of North Africa (BirdLife International, 2017b), breeding is confined to coasts of Mediterranean Sea (Lambertini, 1996). Population size of the species has an interesting historical trend, the total number of Audouin's gull was estimated around 1000 pairs in 1975 (BirdLife International, 2017b), recent population of the species is estimated to be 21600-22000 pairs (Ashpole *et al.*, 2015). 89% of the total population is located on Spanish coasts (Ashpole *et al.*, 2015b) (Table2), Ebro Delta colony was established in 1981 and the population have increased 44% yearly until the beginning of 21st century (Oro & Ruxton, 2001). Now, the colony holds 67% of the global population (Gutierrez & Guinart, 2008). This steep increase in numbers and accumulation of the population in specific areas could be explained by food abundance due to trawler discards (Oro *et al.*, 1996) and other anthropogenic sources such as American crayfish (Navarro *et al.*, 2010). Although trawlers have an important positive effect on breeding success (Oro *et al.*, 1996); such a high increase in population could not be explained only by the high breeding success of the colony, migration from other colonies might be also an important factor (Oro & Ruxton, 2001). This immigration effect indicates that Audouin's gull could migrate from some source populations to form new breeding colonies in suitable places. A breeding colony formed in Alicante, whose source population has been Ebro Delta, is an example of this phenomenon; size of the colony was 31 pairs at the beginning, the number have increased to 298 pairs in one year (Gutierrez & Guinart, 2008).

Table 2 Breeding population sizes and short-term population trends of Audouin's gull. Table is adapted from the report compiled in 2015 by Ashpole *et al.* F represent fluctuating, + represents increasing, - represents declining population size trend. Quality column represents the amount and reliability of the data.

	Population Estimate				**Short-term Population Trend**			
Country	**Size**	**%**	**Years**	**Quality**	**Trend**	**Change (%)**	**Years**	**Quality**
Spain	19461	89	2007	good	F	0	2000-2010	good
Italy	1153-1286	6	2007-2009	medium	+	20-30	2000-2009	medium
Greece	350-500	2	2010	good	-	29-61	1998-2010	good
Portugal	400-460	2	2011	good	+	3200-3800	2001-2012	good
France	82	<1	2008-2011	good	0	12	2001-2012	good
Croatia	60-70	<1	2010	good	?	?		
Turkey	47-90	<1	2013	poor	F	0	2000-2012	poor
Cyprus	14-28	<1	2007-2012	good	-	45-50	2001-2012	medium
Total	21600-22000	100						

Status of Audouin's gull was assessed as Threatened (T) in the end of 1980s (BirdLife International, 2017b). Formation of Ebro Colony; conservation actions (Gallo-Orsi, 2003), and rapid increase in number (Oro & Ruxton, 2001) have caused change in the status to Lower Risk/conservation dependent (LR/cd) (BirdLife International, 2017b) by 1994. IUCN Red List Status of the species has been assessed as Least Concern in 2015 due to its high number and general good status of the populations (BirdLife Interactions, 2017b). However, status of the eastern populations of the species is not as good as the western populations. Breeding colonies in east Mediterranean are small and they are in a declining trend (Table 2). Audouin's gull population on coasts of Greece have declined from 700-900 pairs to 350-500 pairs in the first decade of 2000s (Fric & Trigou, 2012). Monitoring studies conducted at northern coasts of Cyprus revealed that number of the birds has decreased from 15-28 pairs to 13-17 pairs between 2010 and 2016 (Hellicar, 2016).

First breeding records of Turkey population of Audouin's gull belongs to Witt; according to his records there were 28 pairs in 1973, 30 pairs in 1987, 6 pairs in 1996 on Aydıncık Islands, Mersin (Ayaş *et al.*, 2008). The colony of Aydıncık Island expanded to 17 and 16 pairs in 2001 and 2002 respectively, but there was no breeding activity of the species on these islands in 2003. Another breeding colony of the species was observed on a island nearby Karaburun, İzmir. 18 breeding pairs were recorded in 2001, but there was no breeding activity observed in the region following two years (Çağlayan, 2003). Recent properties of the Audouin's gull breeding colonies on Aydıncık Islands will be detailed and discussed further in the result and discussion parts of the thesis. Wintering individuals have also been recorded in midwinter waterbird counts in different regions of Anatolia (Table 3).

Table 3 Number of Audouin's gull and regions they were recorded during midwinter waterbird count studies in last decade. Data are compiled from the reports of each year's report (see references part).

Region	2008	2009	2010	2011	2012	2013	2015	2016	2017	2018
Göksu Delta	-	-	-	-	-	-	-	-	-	10
Milas Airport	3	-	-	-	-	-	-	-	-	-
Ayvalık Tuzla	-	-	-	-	1	-	-	-	-	-
Beymelek Lagoon	-	-	-	-	-	2	-	-	-	-

Audouin's gull was observed all around year on Göksu Delta, between 2009 to 2013; maximum number of individuals recorded were 76 on May 25, 2010, and 10 on June 10, 2013 (Ganzevles, 2013). A subadult individual which was carrying a red ring on left leg was seen in June 2012, code on the ring was not reported (Ganzevles, 2013). When Audouin's gull ringing activities were searched for red ring, it is found that 139 chicks and adults were ringed with red rings on Aegean Islands of Greece, in years 2008, 2009, 2010 (European Colour-Ring Birding, n.d.). This ringed bird suggests bird movement between Aegean population and Northeast Mediterranean region.

There is not a long term monitoring study which could give population trends of marine birds in Northeast Mediterranean which is crucial to elucidate health of marine bird species and marine ecosystem. Also, due to lack of ringing and tracking studies, connectivity between eastern and western populations remains unknown. The knowledge gap in both fields could be narrowed by using genetic markers.

1.5 Genetics

Genetics is the study whose focus is transmission of information decoded on nucleic acids from generation to generation; regions on which this information is coded by sequence of nuclear bases are named genes (Klug *et al.*, 2012). Mendel has defined fundamental concepts of genetics; which are traits, alleles, segregation, genotype, phenotype, dominance. He showed that a trait of an organism is determined by alleles it got from parents, alleles are carried via gametes each gamete carries one of the two alleles of the parent; appearance of the traits, phenotype is depend on dominance of the traits (Mendel, 1866). By the development of molecular techniques, features of proteins (allozymes) are also started to be used in genetics studies (Avise *et al.*, 1987), and amount of the data have started to increase. Interpretation of these data by mathematicians and quantitative biologists Ronald Fisher, B.S. Haldane, S. Wright, G.H. Hardy and W. Weinberg, and by definition of molecular heredity and evolution equations; population genetics was born. Population genetics is concerned with changes of proportion of genes in population, and evolution of species on genetic level (Gillespie, 2004). Diversity in genes of a population, frequencies of alleles, level of divergence from standard models could give information on current status and history of populations. Phylogenetics is another sub-field of genetics, whose focus is history and relationship of species and populations. Phylogenetics uses information of genetic sequence in order to elucidate hereditary connections between ancestors and descendants, their phylogeny (Avise, 2006). Phylogeography is the field where population genetics, phylogenetics and geography met. It studies geographical distribution and connection of genealogical lineages (Emerson & Hewitt, 2005).

Use of population genetics and phylogenetics studies in conservation is widespread today; thanks to development of molecular techniques such as nucleotide sequencing and PCR; and development in interpretation tools and increase in processing power. Voipio's work in 1950 was the first study on which findings of population genetics data is used to advise on natural population management (Allendorf & Luikart, 2007). Use of population genetics, phylogeography and evolution data in order to warn authorities on loss of natural crop populations due to intense agricultural activity (Frankel, 1974) was another leap in conservation biology. Foundational papers of Soule, Frankel, Wilcox, Schönewald-Cox in the beginning of

1980s have placed principals of population genetics as important tools for conservation biology (Meine *et al.*, 2006). Due to their properties of high dispersal range, high level of hybridization, high dependence on environmental conditions; possibility of obtaining large number of samples from large colonies marine birds could be considered as good models for evolutionary biology, ecology and conservation studies on which molecular markers are used (Taylor & Friesen, 2012).

Genes used in understanding structure of populations, or elucidating phylogenetic connections between populations should be neutral against selection in order to obtain true results; otherwise there will be bias caused by natural selection. According to Neutral Theory of Molecular Evolution, most of the allelic variation in genes are neutral; they are not affected by natural selection, but frequencies in the populations change due to genetic drift (Gillespie, 2004). Genetic drift is change in frequencies of alleles due to random sampling of gametes which carries different alleles and conception of them to form next generation (Freeman & Herron, 2001); natural selection has no affect on genetic drift, the process is stochastic. Genetic drift would eventually cause decay of heterozygosity in population and fixation of single allele. According to Wright-Fisher Model, decay of heterozygosity in populations inversely proportional to population size. Decay of heterozygosity is geometric; which means loss of allelic diversity and decrease in heterozygosity would occur in small populations faster and drastically (Gillespie, 2004). Decrease in size and fragmentation of population cause decrease in allelic diversity and level of heterozygosity in small and isolated populations. Even if number of population increase; effects of the past could be observed, this situation is defined by the terms genetic bottleneck and founder effect (Allendorf & Luikart, 2007).

Basic principle of phylogeny is every diploid organism has parents, and the organism has features inherited from them. DNA sequence is one of those features and one of the most reliable one. Level of variation in specific sequences could reveal phylogeny of the populations. Kimura claimed that rate of change in most of the sequences is constant for the region and neutral of natural selection (Gillespie, 2004). Similarities and level of differences between sequences reveal ancestry and evolutionary history of the populations (Hudson, 1991). Each different sequence of a gene region on a chromosome is named haplotype (McKusick & Harper, 2013); haplotypes are used in analytic methods using distance, parsimony, maximum

likelihood and Bayesian inferences; results of these analyses are represented as haplotype networks, or phylogenies (Emerson & Hewitt, 2005). Even there are drawbacks of it (Zink & Barrowclough, 2008; Crochet & Desmarais, 2000) haplotypes of mitochondrial DNA widely used in phylogenetics and phlyogeography. Mitochondrial DNA is abundant in cells, it is more resistant against decaying, isolation of intact mtDNA even from old samples is possible (Avise *et al.*, 1987). Vertebrate mitochondrial DNA is circular with a length of 16000-21000 base pairs; it hosts genes for 22 transfer RNA, 13 enzymes, 2 ribosomal RNA and a control region (Randi & Lucchini, 1998) mutation rate of non-coding parts is relatively fast.

Genetic markers, or DNA markers, are molecular markers used in identification of species, some features of them and relationship with other species (Collard *et al.*, 2005). These loci are generally non-coding and neutral against natural selection. Mitochondrial Control Region (D-Loop), a non-coding locus on mtDNA, is considered as the most variable region on mtDNA (Brown *et al.*, 1986). Control region is the region on which replication of mtDNA starts, it is also promoter for the genes on both heavy and light strand of mtDNA (Yang *et al.*, 2016). Besides its molecular functions, it is a widely used genetic marker in population genetics studies and phylogeny of closely relative species. Length of the region ranges from 1028 bp to 1581 bp for different species, it is divided into three regions: domain I, II and III; substitutions and length variations are mostly concentrated on domain I and domain III of the Control Region (Ruokonen & Kvist, 2002).

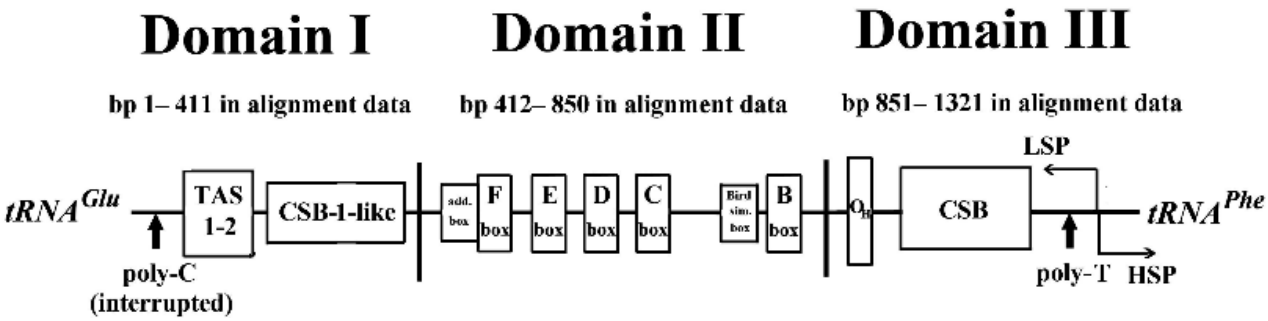

Figure 3 Schematic representation of Laridae Control Region (retrieved from Yang *et al.*, 2016).

Study of Yang and colleagues revealed that seven boxes on Domain II of the Control Region are (Figure 3) highly conserved among *Larus relictus* and five other *Larus* species; a box at upstream of F Box is highly homologous in avian species (Yang *et al.*, 2016). Genetic variability at Domain I and Domain III is high, length of tandem sequences are different and there are insertions and substitutions (Yang *et al.*, 2016). Phylogenetic studies done on 53 gull species by using Control Region Domain II and III and *Cytochrome b* loci of mtDNA revealed that all gull species are in a monophyletic group as defined before (Figure 4). However, phylogenetic relationships of genus *Larus* differs from phylogeny previously suggested by morphology and behavior studies (Pons *et al.*, 2005). Further studies with more outgroups and with more markers are required for more comprehensive results (Pons *et al.*, 2005).

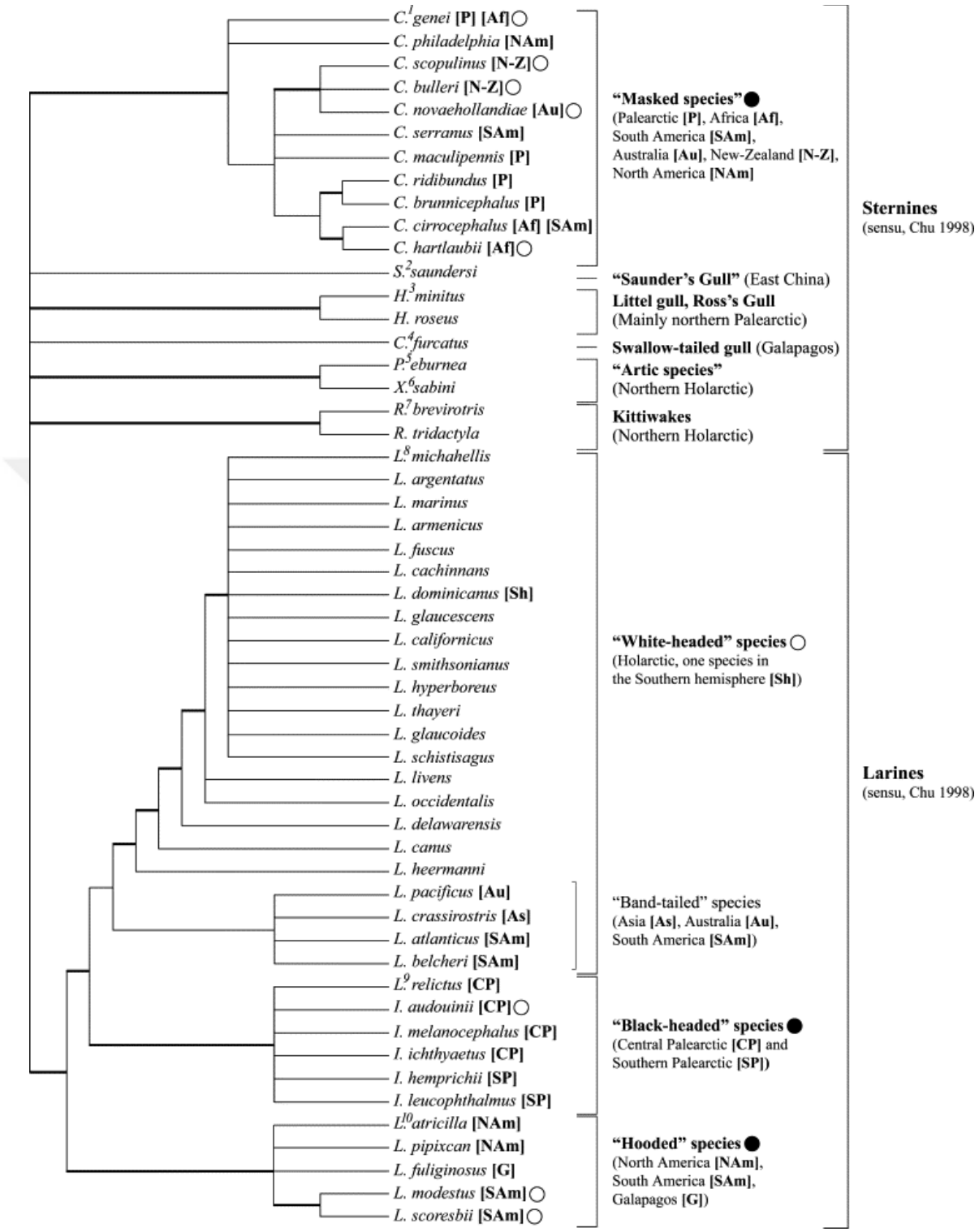

Figure 4 Consensus phylogenetic tree from the Bayesian, maximum likelihood and maximum parsimony analyses; retrieved from Pons *et al.*, 2005

Because of long dispersal range of individuals, gene flow among marine bird populations is high (Crochet *et al.*, 2003); premating selection by sexual imprinting is playing an important role as a barrier against gene flow between populations and species rather than geographic distance (Laland, 1994). When this situation is considered with high level of hybridization in bird species (Pierotti, 1987) speciation of marine birds is become a complicated topic; use of molecular markers is very important to elucidate mechanisms. Crochet and colleagues used mitochondrial DNA marker Cytochrome B, and nuclear markers, microsatellites & allozymes to understand phylogeny and population structure of large white-headed gull species dispersed in North Atlantic (Crochet *et al.*, 2003). While mtDNA marker shows relatively high divergence, nuclear markers have low differentiation levels in frequencies. Such difference between markers could be due to effective sample size difference between mtDNA and nuclear DNA; diploid property of nuclear DNA cause four folds of higher effective population size against haploid mtDNA (Allendorf & Luikart, 2007), a high effective population size could reduce the fixation effect of genetic drift, and cause presence of alleles with similar frequencies (Crochet *et al.*, 2003). Divergence in Cytochrome B sequence suggests starting of diversification in large white headed group of gulls have started between 400000 years and 110000 years ago; high gene flow among populations, and hybridization are continuing (Crochet *et al.*, 2003). Another phylogenetic study was conducted to elucidate population structure and evolution of another marine bird, European shag. Mitochondrial ND2 and Control Region I markers and nuclear microsatellite markers were used in this study. Results of this study revealed structure in populations of this European endemic species; there are three main metapopulations. In addition to that haplotype information, size trend of populations in different regions could be elucidated by using microsatellite markers. Genetic structure of those populations most probably caused by isolation by distance, collapse of populations because of extreme changes in climate, and entrapment in a cryptic northern refugia and known southern refugia during Pleistocene (Thanou *et al.*, 2017). Population genetics could also be used to understand behavior of marine birds. Social monogamy is common in marine birds (Hamer *et al.*, 2001), but being close to potential partners due to colonial breeding increases extra pair coupling probability (Møller & Birkhead, 1993). A genetic study conducted on a large black headed gull colony in Czech Republic in which six polymorphic microsatellite markers were used, revealed that ratio of extra pair parenting is 33% in the colony, and nearly 10% of the chicks are

not genetically matched with both parents, which shows intraspecies brood parasitism (Lezalova-Pialkova, 2011).

Well designed studies on which several genetic tools are used could be done in order to elucidate connectivity, evolution and behavior of the Northeast Mediterranean marine bird populations; these studies would fill the information gap resulting from the lack of comprehensive long term monitoring studies in the region.

Objectives of The Study

Southeast Anatolian Coast of Northeast Mediterranean is an important wintering and breeding ground for marine bird populations. Although amount of nutrient from sea is limited, there are 39 marine bird species recorded in the region, five of them are breeding, but breeding colonies especially Audouin's gull is not in good condition due to habitat loss and intense human activities. This is the first comprehensive study conducted in the region.

Aims of this study are:

1) Survey the breeding marine bird populations in the region, for the size and status of colonies.
2) Find, describe and quantify the habitat features of nesting sites of the marine birds.
3) Reveal relationship between colony status and nesting site properties.
4) See effects of habitat loss, invasive species on breeding marine bird colonies.
5) Provide baseline information for long term monitoring studies and conservation acts.
6) Conduct a primer molecular study in order to elucidate status and recent changes in *Larus aduouinii* population in the region, and reveal its connectivity with other populations.

2-MATERIAL AND METHODS

2.1 Field Studies

2.1.1 Study Area

Breeding bird and habitat surveys were conducted on all islands and islets between Taşucu and 8 km west of Gazipaşa Harbor. This c. 200 km coastline (Figure 5) hosts all islands and islets in Northeast Mediterranean region other than Cyprus and small islands around it. A total of 21 islands larger than 300 m^2 and ones that host vegetation were surveyed. Size of the islands are generally small with a median of 5281 m^2, their distance to mainland is short with a median of 234 m, only distance of one island is more than 2.5 km. Average elevation of islands is 45 m, the highest point is 250 m above sea level. The islands and islets on the study area are limestone origin and most of the surfaces is bare rock. None of the islands has stream or spring on it, the main source of water is rainfall. Vegetation found on islands is mostly shrubs and maquis, annual and biannual plants were also observed on some islands, only the largest island, Dana Island, hosts forest.

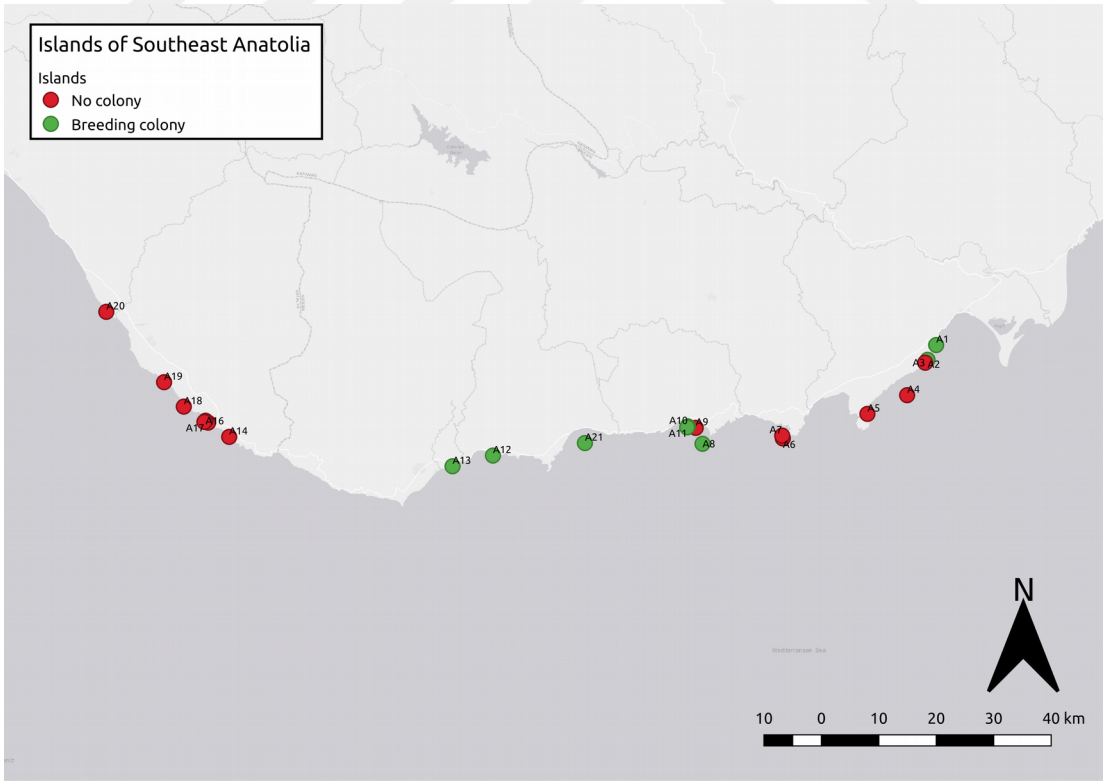

Figure 5 Study area. North East Mediterranean region consists of 21 islands; eight of those islands were hosting marine bird breeding colonies during survey of 2016.

2.1.2 Breeding Bird Survey

Every island in the study area were surveyed for breeding marine birds and also for overall avifauna. The survey was conducted between May 26 and June 4 2016. On each surveyed island, number of adult marine birds was estimated. This estimation has been done by counting both perched and flying individuals over island. The population counts were done three times, first at the arrival to the island by circling around the island by boat; second at the beginning of the land survey from the highest point on the island; third at the end of the land survey again from the top of the island. Furthermore, nest and juvenile densities were estimated by using transect counts. Two orthogonal transects were defined covering the longest two dimensions of the island. Researchers walked over the transect with a slow pace and as direct as possible., but transects were frequently blocked by cliffs and dense shrubs, and because of that it was not always possible to keep a straight transect. In addition to that, it was not feasible to cover the entire island in case of Dana Island, the largest island in the study region, by using the orthogonal transect method previously described. Therefore, four transects perpendicular to coast and up to 75 m high were surveyed in that island.

Transects were divided into habitat sections according to dominant vegetation type covered the area. Number of nests, eggs, and juveniles were recorded within a 3 m distance on each side for each habitat section of transects. Torso and culmen length were measured for chicks and dimensions of eggs were measured by calipers, but those data are not used in analyses. During the transect surveys, a standard breeding bird count (Bibby, 2004) was also performed for avifauna other than marine birds. Any birds has been seen or heard was recorded with its abundance and relevant breeding code (Table 4). Any bird encountered outside of transect survey was recorded as an opportunistic count.

Breeding marine bird count surveys were repeated on Major and Minor Aydıncık Islands, Yılanlı Island and Yelkenli Island in 2017 and 2018 breeding seasons. In these surveys flying bird counts were done to reveal colony sizes.

Table 4 Breeding codes used in surveys. Codes are adapted from Herrando *et al.*, n.d.

Code	Explanation	Breeding Status
FO	Flying Over	none
0	Habitat is NOT suitable for breeding	none
1	Adult in SUITABLE HABITAT in breeding season	possible
2	SINGING MALE	possible
3	COUPLE in suitable habitat	probable
4	Bird holding TERRITORY	probable
5	COURTSHIP display or MATING	probable
6	Adult visiting PROBABLE NEST-site	probable
7	AGITATED behavior	probable
8	Brood patch in adults	probable
9	NEST BUILDING	probable
10	DISTRACTION DISPLAY	certain
11	OCCUPIED nest or EGG fragments	certain
12	YOUNG recently fledged or downy	certain
13	Used NEST	certain
14	Adult carrying FECAL SAC or FOOD	certain
15	EGG in nest	certain
16	YOUNG in nest	certain

Furthermore, throughout the cruise, the entire coastline and seascape have been surveyed for marine birds and potential breeding colonies by a surveyor on the deck. Coordinates, abundance, breeding code and the age group (when applicable) were recorded as opportunistic counts. Sites with potential marine breeding colonies on the coastline were carefully examined for breeding evidence and total number of nests.

In order to reveal relationship between breeding colony size and distance from the mainland relationship closest distance between mainland and coasts of islands are measured on satellite imagery.

2.1.3. Habitat Survey

2.1.3.a Transect Survey

Main habitat types on islands were quantified by using standardized transect method. Transects were divided into sections according to vegetation type and physical characteristics of the region. Coordinates and altitude of the points on which vegetation and characteristics of habitat is changed were recorded and the transects were divided into habitat sections accordingly. Dominant plant species were sampled by a plant press and photographed to be identified later. All the main habitat types encountered during the survey were listed on Table 5. Evidences of presence of mammals, as feces and foot prints, on transects were recorded.

Table 5 Description of habitat types observed during habitat survey.

No.	Habitat Type	Description
1	Beach	Shore covered by sand or pebbles with low slope
2	Bushes	Area covered by perennial short plants
3	Forest	Area covered by trees, mostly pine species
4	Forb	Area covered by annual, dicotyledonous plants.
5	Maquis	Area covered by typical mid length bushes of Mediterranean climate
6	Olive Stand	Area covered by olive trees planted by humans
7	Rocky Shore	Low to moderate slope rocky coastline
8	Grass	Area covered by monocotyledonous gramineae plants

Area of different habitat types and habitat coverage percentages on islands are interpreted on QGIS Software (QGIS Development Team,2018) polygons for habitat types created by interpolating the transect data on Google Maps Imagery (Google Maps, 2017).

2.1.3.b Mammal Presence on Islands

Mammal presence survey on the islands were done during transect surveys by checking presence of prints or feces of mammals; data of this surveys are categorical (present, absent).

2.1.4 Genetic Sampling

Minimum four feather samples were taken from plumage at posterior dorsal of the chicks and juvenile gulls, after measurements of torso and culmen were done. Feather samples were taken into 1.5 ml sterile centrifuge tubes; 90% ethanol is added on the deck, and samples were kept in -20°C to keep DNA of the samples intact. Tissue samples were also taken from dead individuals if any was encountered. Species identification of the specimens were done by using species definitions from Snow and Perrins, 1998.

In addition to Southeast Anatolia samples, in order to elucidate genetic structure and connectivity of metapopulation (Figure 6) of Audouin's gull; feather samples from *Larus audouinii* breeding at Northeast Cyprus were also taken by our collaborators Damla Beton and Robin Snape from Kuşkor Society with the method described above and were sent to METU IMS by snail mail.

2 ml blood samples were taken from *L. audouinii* chicks of Ebro Colony by collaborator Dr. Daniel Oro's group at IMEDEA, Spain. Blood samples were kept in 90% ethanol and sent to METU IMS by snail mail. Details of genetic samples are given on Table 6.

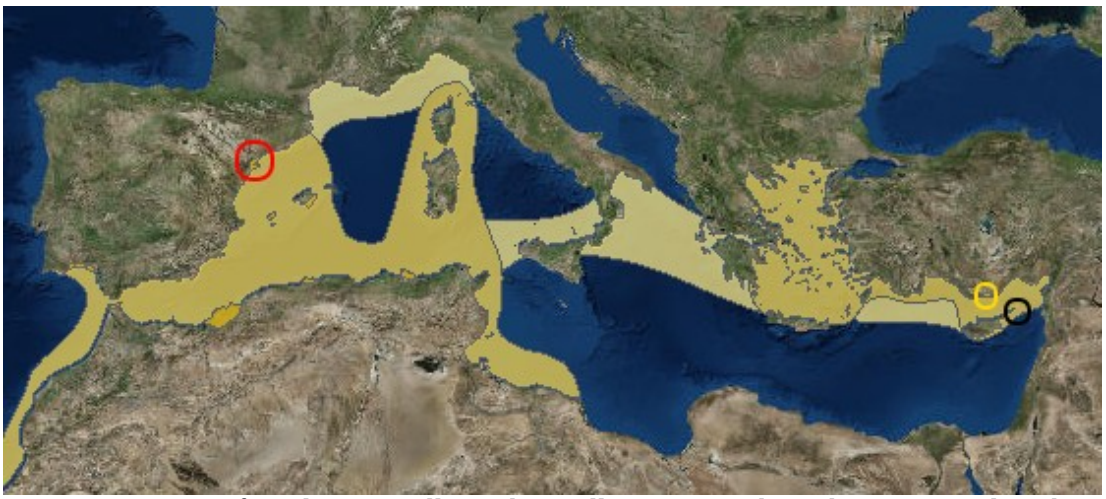

Figure 6 Range of Audouin's gull. Darker yellow regions have been reported to host breeding colonies. Faintest yellow regions are representing potential dispersal routes. Red, yellow and black circles are representing sampling locations; Ebro Delta, Aydıncık Islands and Cyprus respectively. The map has been taken from BirdLife, 2017b and modified.

Table 6 Type and number of genetic samples. Yılanlı Ada and Küçük Ada Samples were taken during surveys; Ebro Delta and Cyprus samples were provided by Oro *et. al* and Beton *et al.* respectively.

Species	Colony	Year	Type	Letter Code	Number
L.audouinii	Yılanlı Island	2016	Feather	A	5
L.audouinii	Yılanlı Island	2016	Tissue	A	5
L.audouinii	Ebro Delta	2016	Blood	C	14
L.audouinii	Aydıncık Minor Island	2017	Feather	E	16
L.audouinii	Cyprus	2017	Feather	D	9
L.michahellis	Yılanlı Island	2016	Feather	B	11

2.2 Laboratory Work

2.2.1 DNA Extraction from the Samples

Genetic samples kept in %90 ethanol at -20 °C were processed in Molecular Biology and Genetics Laboratory of METU Institute of Marine Sciences. CTAB extraction protocol (Winnepenninckx *et al.,* 1993) modified and used to isolate DNA from all specimens. CTAB (cetyltrimethylammounium bromide) containing extraction buffer behaves as a detergent, lyse cells; CTAB in the buffer effectively eliminates polysaccharides by binding those molecules in high salt conditions (Clarke, 2013); because of keratin content of feathers that property of the reagent is crucial. 2-merchaptoethanol in the lysis solution is a reagent for lysis of cells and extraction of DNA it breaks dissulfide bonds in structure of proteins. Proteinase K is used for degradation of proteins.

All chemicals and reagents used in DNA extraction and their properties are listed below:

-CTAB buffer:

In 1 L:

580 ml ddH_2O

280 ml 5 M NaCl

100 ml 1 M Tris HCl pH 8.0

40 ml 0.5 M EDTA

20 g CTAB

- β-Mercaptoethanol
- Proteinase K (Sigma P4850, >800 units/ml)
- Choloroform : Isoamyl Alcohol (cold)
  24:1
- 70% Ethanol
-Isopropanol (Ice cold)
- 1X TE Buffer

2.2.1.a DNA Extraction from Feather Samples

-A piece around 1 mm is cut from tip of feather, placed in 1.5 ml microcentrifuge tube.
-600 µl CTAB buffer added to tubes.
-50 µl β-Mercaptoethanol added.
-2 µl of Proteinase K is added to solution.
-Overnight incubation at 37 °C 500 rpm.
-Incubate samples at 55 °C 500 rpm for 1.5 hour.
-After incubation, samples are placed on ice.
- 500 µl Cholorform: Isoamyl Alcohol is added.
-Samples are mixed until see milky-white color.
-Samples are centrifuged at 14000 rpm for 15 minutes.
-Phase separation observed after centrifuge, upper phase contains DNA, upper phase is taken carefully and placed into a new sterile 1.5 ml microcentrifuge tube.
-300 µl Isopropanol is added to samples.
-Overnight incubation at -20 °C.
-Tubes are centrifuged at 14000 rpm for 15 minutes.
-Supernatant is discarded.
- 1000 µl 70% EtOH at 4 °C is added for washing steps.
-Tubes are centrifuged at 14000 rpm for 15 minutes, supernatant discarded. Last two steps are repeated 3 times.
-Samples are let to be dried in fume hood.
-50 µl TE Buffer is added to samples and samples are kept in -20°C.

2.2.1.b DNA Extraction from Blood Samples

-Take 60 µl of EtOH-blood mix (blood is clotted, it is like small precipitates in EtOH) , place in 1.5 ml microcentrifuge tube.
-600 µl CTAB buffer added to tubes.
-50 µl β-Mercaptoethanol added.
-2 µl of Proteinase K is added to solution.
-Overnight incubation at 37 °C 500 rpm.
-Incubate samples at 55 °C 500 rpm for 1.5 hour.
-After incubation, samples are placed on ice.
- 500 µl Cholorform: Isoamyl Alcohol is added.
-Samples are mixed until see milky-white color.
-Samples are centrifuged at 14000 rpm for 15 minutes.
-Phase separation observed after centrifuge, upper phase contains DNA, upper phase is taken carefully and placed into a new sterile 1.5 ml microcentrifuge tube.
-300 µl Isopropanol is added to samples.
-Overnight incubation at -20 °C.
-Tubes are centrifuged at 14000 rpm for 15 minutes.
-Supernatant is discarded.
- 1000 µl 70% EtOH at 4 °C is added for washing steps.
-Tubes are centrifuged at 14000 rpm for 15 minutes, supernatant discarded. Last two steps are repeated 3 times.
-Samples are let to be dried in fume hood.
-50 µl TE Buffer is added to samples and samples are kept in -20°C.

Quantity and quality of isolated DNA was measured in Inovia Technology MSP-100, micro-volume spectrophotometer.

2.2.2 Gene Amplification

ThermoFisher 2X Master mix (Lot no K0171) is used in gene amplifications. The master mix contains Taq DNA polymerase (0.05 U/µL), reaction buffer, 4 mM $MgCl_2$, 0.4 mM of each dNTP (Thermo Scientific, 2012).

PHDL (5'-AGGACTACGGCTTGAAAAGC-3') and PHDH (5'-CATCTTGGCATCTTCAGTGCC-3') were used to amplify entire Control Region (D-Loop) of mitochondrial DNA (Fumihito *et al.* 1995) by polymerase chain reaction. The amplifications were performed with a final volume of 40 µl (20 µl Master Mix, 17 µl dH_2O, 0.5 µl Forward Primer, 0.5 µl Reverse Primer, 2 µl sample) in ThermoFisher Master Mix trials. Polymerase Chain Reaction is done in BIO-RAD T100 Thermal Cycler. Cycling conditions were given in table 7. Success of PCR were checked by agarose gel electrophoresis (2% agarose in TAE buffer; 90 V, 90 mins run). A region c. 1100 bp is amplified in PCR; no band was observed in any negative control.

Table 7 PCR conditions

Temparature	Duration	Cycle
94 °C	2 minutes	
94 °C	15 seconds	36 X
57 °C	15 seconds	
72 °C	1 minute	
72 °C	10 minutes	

2.2.3 Sequencing

Paired end sequencing of 18 samples (B17, C2, C4, C6, C7, C8, C9, C10, C12, C13, D2, D7, D8, D9, E4, E5, E6, E10) is ordered from a company, Macrogen Inc. PCR confirmed samples and primers were prepared by following the instructions given by the company (Macrogen Inc, 2017) and send to be sequenced. Macrogen is using Applied Biosystems 3730 DNA Analyzer (Macrogen Corp., 2017); paired end sequencing of the samples are done in capillary system whose basic principle is Sanger's Chain Termination Method (Sanger & Coulson, 1975). Sequencing results and chromotograms were sent by the company.

Trimming of low quality readings, alignment of reverse and forward sequence readings of the same regions are done in MEGA X (version 10.0.4). Alignment of sequences are done by using Clustal W tool in MEGA X Software (Kumar *et al.*, 2018); evolutionary divergence analyses of 17 samples on 656 base pair regions were done by using MEGA X which uses composite likelihood model (Tamura *et al.*, 2004). Due to extremely low diversity, no further intra-species phylogenetic analyses applied to samples. Aligned sequence is analyzed by using NCBI BLAST (Altschul, 1990) in order to see level of match with other sequences on the NCBI GenBank database.

2.3 Phylogenetic Analyses

Trimmed and aligned 656 bp part of the Control region sequence of the *L.audouinii* samples have been aligned with complete mitochondrial genome of *Larus relictus (Seq. ID: KC760146.1), and* Mitochondrial Control Region sequences of 94 *Larus* species obtained from GenBank. Pairwise distances between all sequences and overall mean distance was calculated by using MEGA X (version 10.0.4) (Kumar *et al.*, 2018); Tamura-Nei Model used for substitutions. Phylogeny of the species is revealed by using Maximum Likelihood method based on Tamura-Nei Model. Initial trees for hueristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the MCL approach. Likelihood of the tree tested by 500 bootstraps (Kumar *et al.* 2008).

2.4 Data Analyses and Statistics

2.4.1 Breeding Bird and Habitat Survey

Area of different habitat types and habitat coverage percentages on islands are measured on QGIS Software (QGIS Development Team, 2018) by using polygons created by interpolating transect information on Google Maps Imagery (Google Maps, 2017). This coverage percentages are used in order to understand effect of invasive mammals on vegetation type; due to non-normal distribution of variables, non parametric Wilcoxon Rank Sum Test is applied (Campbell & Swinscow, 2009) to see whether presence of mammals has a significant effect on distribution of annual-biannual plants or not.

Habitat type-gull nest density relationship is elucidated by using habitat area and nest number values from transect survey. Surveyed area is calculated by multiplying transect length with six, coming from the 3 m, range on both sides of transect line. Nest density values are given in nest number per hectare for convenience. Non-parametric Kruskal-Wallis Test is applied to understand affect of habitat type on nest density (Campbell & Swinscow, 2009). In addition to nest density analyses for different habitat types; habitat types are pooled according to type of vegetation as herbaceous, woody and no vegetation. Kruskal-Wallis test is also applied to pooled data. Correlation between number of flying marine bird on islands and nest number was tested by using Pearson’s Correlation Test (Campbell, 2006). Non-parametric Spearman Rank Correlation test is applied to see the relationship between distance and nest density. All analyses and statistical tests were conducted in R environment (R Core Team, 2018).

3-RESULTS

3.1 Field Studies

3.1.1 Breeding Bird Survey

Eight breeding colonies of Yellow-legged gull, three breeding colonies of European shag and one breeding colony of Audouin's gull have been found during the survey. 12 of 21 islands had marine bird activity (Table 8) and eight island hosted marine bird colonies (Table 9), nests were detected on seven islands (gulls were showing territorial defense behavior on Bozyazı Island (I12), but no nest were seen on transect survey). The population estimates based on flying birds revealed the population sizes of c. 200 pairs for *L. michahellis*, c. 15 pairs of *P.aristotelis* and eight pairs of *L.audoinii*. 55 nests of *L.michahellis,* 7 nests of *L.audounii* were recorded in transect surveys. Eggs and chicks of different age groups are observed in or nearby those nests. Some Yellow-legged gull juveniles were fledged and started to fly short distances; when c. 27 days of incubation and c. 45 days of fledgling time for Yellow-legged gull are considered (Schreiber & Burger, 2001b), breeding activities of the Yellow-legged gull is inferred to be started at the beginning of March. Audouin's gull chicks were younger compared to Yellow-legged gull chicks. When c. 30 days of incubation and c. 35 days of fledgling for Audouin's gull (Schreiber & Burger, 2001b); Audouin's gull colony has laid eggs likely on the first week of April. The nest counts during the transect surveys and flying bird counts (Table 8) correlated significantly (Spearman's Correlation test; rho= 0.91, $p << 0.05$). Scopoli's shearwater (*Calonectris diomedea*) was observed at two locations . However, no breeding evidence was found.

Table 8 Count of flying gulls on islands, and number of nests detected in transect survey. All counts are from 2016 survey.

Island	Flying Bird Count	Nest Number
I1	170	24
I2	40	1
I4	0	0
I5	3	0
I6	2	0
I7	1	0
I8	50	16
I9	0	0
I10	35	11
I11	50	4
I12	15	0
I13	40	4
I14	3	0
I21	25	2

Table 9 Estimated colony sizes on islands on 2016 breeding season.

	Estimated Colony Size (Pairs)								
Species \ Island	I1	I2	I8	I10	I11	I12	I13	I21	Total
Phalacrocorax aristotelis	4-8		1-2					2-5	7-15
Larus audouinii			6-8						6-8
Larus michahellis	65-85	10-20	15-20	10-12	25-30	6-8	13-15	5-10	150-200

Audouin’s gull breeding colony have been recorded on Minor Aydıncık Island in the surveys of 2017 and 2018 (Table 10). The colony was located on southwest of the island. Colony size of the species was estimated to be 7-10 pairs in 2017 and 2018. Yellow-legged gull breeding colonies were also observed on Yılanlı, Minor and Major Aydıncık Islands, but no breeding activity was observed on Yelkenli Island.

Yellow-legged gull breeding colonies have been recorded on Yılanlı Island, Minor and Major Aydıncık Islands (Table 11) in the last three years. No counting of Yellow-legged gulls on Minor and Major Aydıncık Islands has been done in 2017 survey.

Table 10 Flying bird counts for Audouin's gull on breeding seasons of last three years.

Island	2016	2017	2018
I8	13	0	0
I9	0	0	0
I10	0	20	15
I11	0	0	0

Table 11 Flying bird counts for Yellow-legged gull on breeding seasons of the last three yars. Note that Yellow-legged gull record I10 and I11 were not kept due to focus on Audouin's gull

Island	2016	2017	2018
I8	37	90	35
I9	0	0	0
I10	35	NA	25
I11	50	NA	40

3.1.2 Habitat Survey

3.1.2.a Transect Survey

In total, 14 islands were surveyed with standardized transect method. Total length of transects is 5407 meters (Table 12), area covered by transect survey is c. 32400 square meters. Shrub habitat type has been covering largest part of it (Table 13, Figure 7). Eight habitat types were observed in habitat surveys. Habitat coverage as transect length and interpolation on satellite imagery were significantly correlated (Spearman Correlation Test, rho=0.96, $p < 0.05$) except for Dana Island (Table 14). Due to large dimensions of the island we did not cover all axes of the island, but we have done four transects on the island to define habitat types. Shrub habitat type was dominant habitat type in transect survey, followed by rock and maquis habitat types respectively.

Table 12 Habitat distribution along transect lengths. Values are in meters and they were rounded to up for convenience.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	0	0	0	0	70	0	70	641	781
2	0	0	0	0	0	0	66	62	128
4	0	0	172	0	322	0	150	182	826
5	12	111	0	0	200	0	191	180	694
6	0	0	0	0	274	0	229	358	861
7	0	0	0	0	249	0	221	197	667
8	0	19	0	47	0	0	144	0	210
9	0	0	0	0	0	0	77	113	190
10	0	0	0	0	0	0	90	107	197
11	0	0	0	0	42	0	91	190	323
12	5	0	0	0	28	107	64	37	241
13	0	16	0	0	0	0	35	0	50
14	0	0	0	0	27	0	42	0	69
21	0	49	0	0	0	0	120	0	169
Total	17	195	172	47	1212	107	1590	2067	5407

Table 13 Percentage of habitat types on transects.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	0	0	0	0	8.96	0	8.96	82.07	100
2	0	0	0	0	0	0	51.56	48.44	100
4	0	0	20.82	0	38.98	0	18.16	22.03	100
5	1.72	15.99	0	0	28.82	0	27.52	25.94	100
6	0	0	0	0	31.82	0	26.60	41.58	100
7	0	0	0	0	3.33	0	33.13	29.54	100
8	0	9.05	0	22.38	0	0	68.57	0	100
9	0	0	0	0	0	0	40.53	59.47	100
10	0	0	0	0	0	0	45.69	54.31	100
11	0	0	0	0	13.00	0	28.17	58.82	100
12	2.07	0	0	0	11.62	44.39	26.56	15.35	100
13	0	31.37	0		0	0	68.63	0	100
14	0	0	0	0	39.13	0	60.87	0	100
21	0	28.99	0	0	0	0	71.01	0	100
Total	0.31	3.61	3.18	0.87	22.42	1.98	29.41	38.23	100

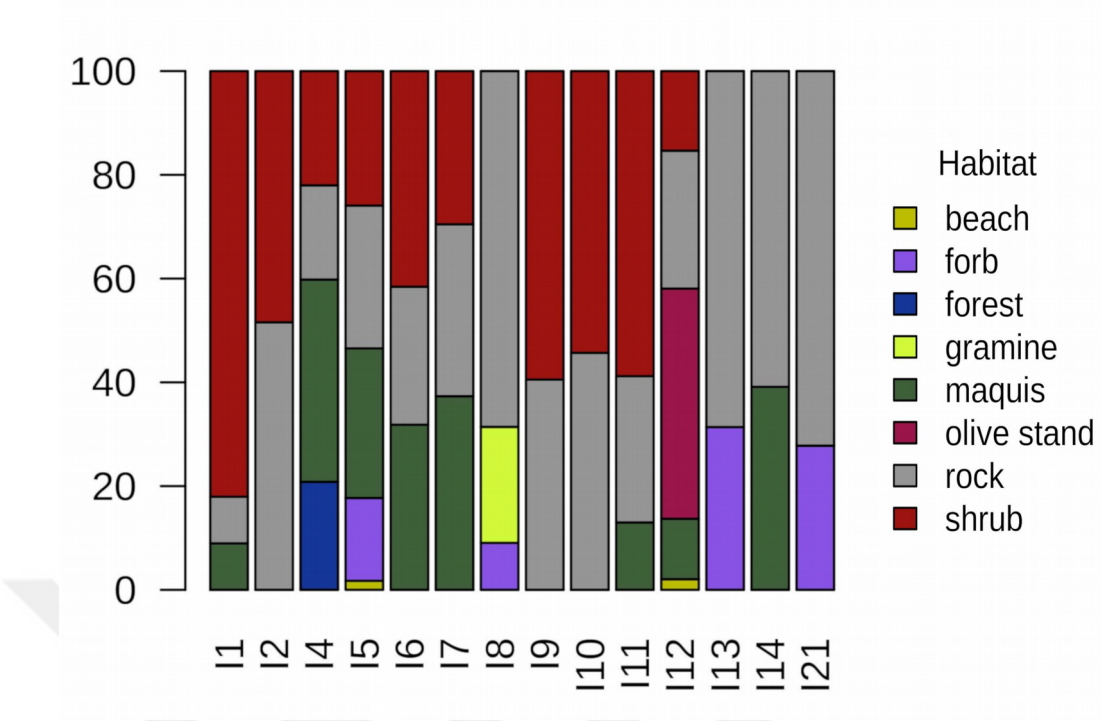

Figure 7 Percentage coverage of habitat types on islands according to transect surveys. Island codes are on x-axis, percentage are given on y-axis.

Table 14 Comparison of habitat percentage coverage. Notice that, Dana Island is excluded due to difference of its properties from the other islands.

Habitat Type	Transect Survey	Satellite
Beach	0.37	0.31
Forb	5.30	4.35
Grass	1.03	0.49
Maquis	19.43	10.56
Olive Stand	2.34	0.81
Rock	30.39	43.92
Shrub	41.15	39.57

62 gull nests have been recorded on seven islands in transect survey. 39 of them were in shrub habitat type, 10 nests were recorded in grass habitat type eight nests have been seen on forb habitat type (Table 15), 12 juveniles were also recorded. In addition to those, 12 dead gulls were detected on transect survey; 5 of those on Yılanlı Island and they were *L.audouinii* chicks.

Table 15 Number of nests detected in transect surveys.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	NA	NA	NA	NA	1	NA	0	23	24
2	NA	NA	NA	NA	NA	NA	0	1	1
4	NA	NA	0	NA	0	NA	0	0	0
5	0	0	NA	NA	0	NA	0	0	0
6	NA	NA	NA	NA	0	NA	0	0	0
7	NA	NA	NA	NA	0	NA	0	0	0
8	NA	5	NA	10	NA	NA	1	NA	16
9	NA	NA	NA	NA	NA	NA	0	0	0
10	NA	NA	NA	NA	NA	NA	0	11	11
11	NA	NA	NA	NA	0	NA	0	4	4
12	0	NA	NA	NA	0	0	0	0	0
13	NA	1	NA	NA	NA	NA	3	NA	4
14	NA	NA	NA	NA	0	NA	0	NA	0
21	NA	2	NA	NA	NA	NA	0	NA	2
Total	0	8	0	10	1	0	4	39	62

Nest densities on habitat types and islands were calculated by using nest number and transect coverage, and given as nest number per hectare for convenience. Shrub habitat type hosted the highest number of nests, grass habitat type has the highest density by 354.61 nests per hectare; forb habitat type follows it by 69.08 nests, and shrub habitat type has 31.45 nests per hectare (Table 16). Nest density values on different habitat types show different distribution patterns on different islands, and high nest density on grass habitat type is noticeable (Figure 8). When nest density distribution on herbaceous and woody plant covered areas are compared, noticeable effect of vegetation type on nest density is clear (Figure 9). Also, Kruskal-Wallis test has attained statistical significance on pooled data (Kruskal-Wallis chi-squared = 6.7258, df = 2, p-value = 0.03463). Besides those findings, nest density is not homogeneously distributed on seven colony hosting islands (Figure 10, mean = 65.49, sd=52.07).

Table 16 Nest densities on different habitat types and islands. Values are given as nest number per hectare.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	NA	NA	NA	NA	30.86	NA	0	59.80	51.22
2	NA	NA	NA	NA	NA	NA	0	26.88	13.02
4	NA	NA	0	NA	0	NA	0	0	0
5	0	0	NA	NA	0	NA	0	0	0
6	NA	NA	NA	NA	0	NA	0	0	0
7	NA	NA	NA	NA	0	NA	0	0	0
8	NA	438.60	NA	354.61	NA	NA	11.57	NA	126.98
9	NA	NA	NA	NA	NA	NA	0	0	0
10	NA	NA	NA	NA	NA	NA	0	171.34	93.06
11	NA	NA	NA	NA	0	NA	0	35.09	20.64
12	0	NA	NA	NA	0	0	0	0	0
13	NA	104.17	NA	NA	NA	NA	142.86	NA	130.72
14	NA	NA	NA	NA	0	NA	0	NA	0
21	NA	70.92	NA	NA	NA	NA	0	NA	19.72
Total	0	69.08	0	354.61	1.38	0	4.18	31.45	19.11

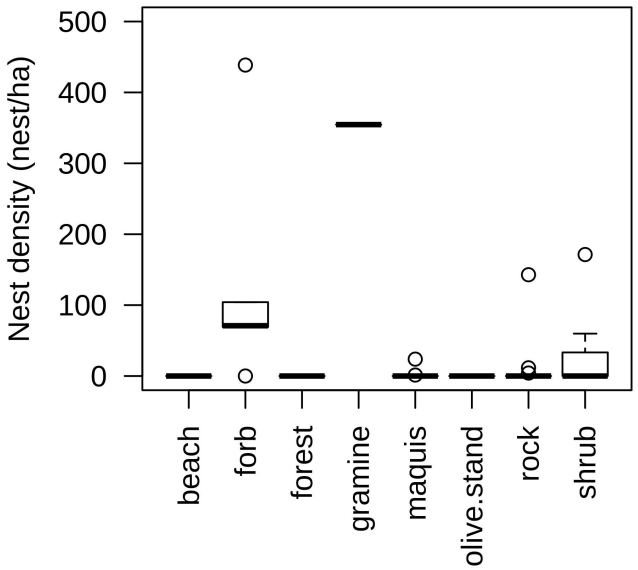

Figure 8 Distribution of nest densities at different habitat types on different islands.

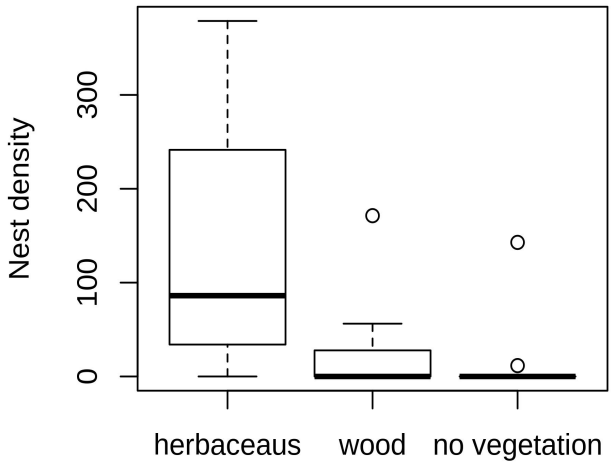

Figure 9 Distribution of nest densities at different pooled vegetation types.

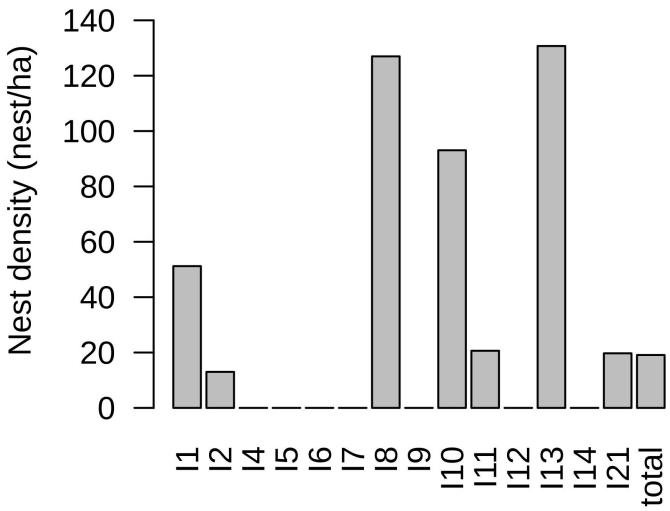

Figure 10 Distribution of nest densities on colony hosting islands. Codes of islands were given on x axis. “Total” represents nest density on all survey area.

No significant correlation between nest density and distance to mainland (Table 17) is found (Spearman Correlation Test, rho=0.40, P=0.5).

Table 17 Nest densities on islands and distances to closest point on mainland.

Island	Nest Density (nest/ha)	Distance to mainland (m)
I1	51.22	351
I2	13.02	234
I4	0	2262
I5	0	214
I6	0	540
I7	0	529
I8	126.98	1795
I9	0	32
I10	93.06	638
I11	20.61	728
I12	0	197
I13	130.72	297
I14	0	47
I21	19.72	2592

3.1.2.b Whole Island Habitat

Islands of the interest cover c. three million square meters; the largest island Dana Island (I4) covers c. 2.7 million square meters (Table 18) and dominates calculations on habitat types. Habitat properties of Dana island are different from the other islands. This situation affects habitat coverage estimations significantly (Table 18); for example, it is the only island hosting forest habitat type, and that forest covers a large area which is equal to 16.21 % of total studied area (Table 19) which makes it fourth most common habitat type on the islands. However there is not any region on other islands defined as forest habitat type (Figure 11).

Table 18 Area of habitat types on Islands. Values are given in square meters, decimals of the numbers rounded up for convenience.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	0	0	0	0	4627	0	10584	59296	74508
2	0	0	0	0	0	0	3335	1086	4421
4	0	0	499544	0	787500	0	420610	972832	2680486
5	802	15979	0	0	12065	0	28983	5683	63511
6	0	0	0	0	11541	0	54302	63994	129837
7	0	0	0	0	9855	0	25840	12249	47944
8	0	954	0	1959	0	0	6372	0	9285
9	0	0	0	0	0	0	10305	2066	12371
10	0	0	0	0	0	0	10094	1880	11975
11	0	0	0	0	2200	0	10815	11836	24851
12	454	0	0	0	861	3228	6713	538	11794
13	0	166	0	0	0	0	1865	0	2031
14	0	0	0	0	1192	0	3931	0	5123
21	0	326	0	0	0	0	2942	0	3268
Total	1256	17425	499544	1959	829843	3228	596691	1131461	3081406

Eight habitat types were observed on islands during transect surveys. Interpolation of transect survey data on air photographs revealed that shrub, rock and maquis habitat types are the most dominant habitat types on surveyed islands, respectively (Table 19, figure 11). When Dana Island excluded from estimations; rock becomes the most dominant habitat type; its coverage increase to 43.92% from 29.36% the shrub habitat type follows it; whose coverage increase to 39.57% from 36.72%. Maquis habitat type is the third most common habitat type; its coverage decline from 26.93% to 10.56%, . Beach, grass and olive stand habitat types are the least common habitat types; their percentage coverage are less than or equal to 0.1% when estimations were done by including Dana Island (Table 19). Ratio of olive stand increase to 0.81%, grass coverage increase to 0.49%, and beach habitat type increase to 0.31% by the exclusion of Dana Island from the estimation.

Slopes are calculated according to data from transect surveys; zones with a slope larger than 50º are considered as cliffs. All cliffs in the study area are covered by rocks and they constitutes 5% of the total transect survey area. There are platforms, cracks, cavities and small caves on cliffs.

Table 19 Percentage of habitat types on islands.

Island	Beach	Forb	Forest	Grass	Maquis	Olive Stand	Rock	Shrub	Total
1	0	0	0	0	6.21	0	14.21	79.58	100.00
2	0	0	0	0	0	0	75.43	24.57	100.00
4	0	0	18.64	0	29.38	0	15.69	36.29	100.00
5	1.26	25.16	0	0	19.00	0	45.63	8.95	100.00
6	0	0	0	0	8.89	0	41.82	49	100.00
7	0	0	0	0	20.55	0	53.90	25.55	100.00
8	0	10.28	0	21.09	0	0	68.63	0	100.00
9	0	0	0	0	0	0	83.30	16.70	100.00
10	0	0	0	0	0	0	84.30	15.70	100.00
11	0	0	0	0	8.85	0	43.52	47.63	100.00
12	3.85	0	0	0	7.30	27.37	56.91	4.56	100.00
13	0	8.17	0	0	0	0	91.83	0	100.00
14	0	0	0	0	23.27	0	76.73	0	100.00
21	0	9.97	0	0	0	0	90.03	0	100.00
Total	0.04	0.57	16.21	0.06	26.93	0.10	29.36	36.72	100.00

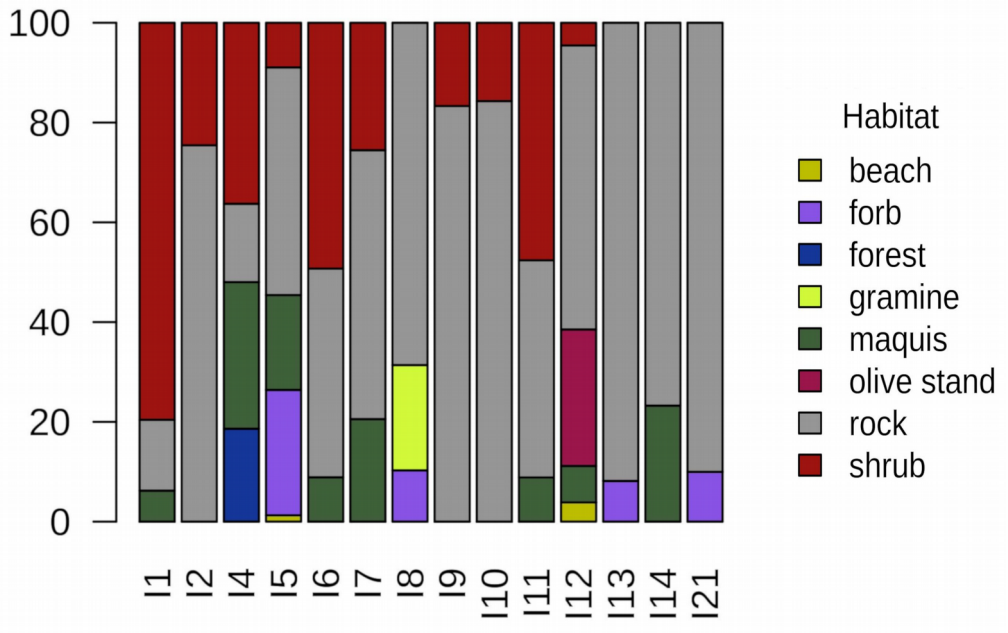

Figure 11 Percentage coverage of habitat types on island estimated by extrapolation of transect survey on satellite imagery. Island codes are on x-axis, percentage are given on y-axis.

3.2 Description of Islands

Table 20 Properties of Islands in the region

Island (code)	Latitude	Longitude	Area (m^2)	Max Alt. (m)	Distance to Mainland (m)
Boğsak Island (I1)	36°16'01.02"N	33°49'38.04"E	74508	43	351
Güvercin Island (I2)	36°14'38.53"N	33°48'38.03"E	4421	9	234
Güvercin Islet (I3)	36°14'22.53"N	33°48'22.29"E	316		22
Dana Island (I4)	36°11'21.17"N	33°46'17.13"E	2680486	250	2262
Kösrelik Island (I5)	36° 9'36.69"N	33°41'42.46"E	63511	45	214
Beşparmak Major Island (I6)	36° 7'19.74"N	33°31'57.59"E	129837	107	540
Beşparmak Minor Island (I7)	36° 7'35.30"N	33°31'53.14"E	47944	50	529
Yılanlı Island (I8)	36° 6'49.65"N	33°22'42.16"E	9285	17	1795
Yelkenli Island (I9)	36° 8'18.74"N	33°21'55.11"E	12371	12	32
Aydıncık Minor Island (I10)	36° 8'26.98"N	33°21'0.14"E	11975	4	638
Aydıncık Major Island (I11)	36° 8'21.65"N	33°20'56.30"E	24851	26	728
Bozyazı Island (I12)	36° 5'44.04"N	32°58'32.80"E	11794	16	197
Mamure Island (I13)	36° 4'44.17"N	32°53'53.46"E	2031	6	297
Yalcılı Island (I14)	36° 7'28.43"N	32°28'8.97"E	5123	29	47
Çıpçılı Islet (I15)	36° 8'47.88"N	32°25'43.17"E	2042		165
Kalaytaşı Island (I16)	36° 8'58.57"N	32°25'25.22"E	3297		12
Kurt Island (I17)	36° 8'51.84"N	32°25'17.52"E	2862		352
Doğanlı Island (I18)	36°10'17.36"N	32°22'55.10"E	731		16
Ilısu Island (I19)	36°12'33.79"N	32°20'38.74"E	864		219
Kuzu Islet (I20)	36°19'6.15"N	32°13'59.24"E	689		54
Aksaz Island (I21)	36° 6'53.82"N	33° 9'8.95"E	3268	12	2592

I1 Boğsak Island

Boğsak Island is a karst island 351 m away from the mainland. It covers c. 74500 m^2. Two longest axes of the island are 469 m and 257 m on which transect survey was conducted. The highest point on the island is 43 m above sea level. The island has a smooth slope; there is a cliff on the southern end. Maquis and shrub are the dominant vegetation type on island (Table 21), and their closeness is very high (Table 22), especially on the inner parts of the island. The island is largely covered with ruins.

The island hosted a large colony of Yellow-legged gull consists of c.170 individuals. We have recorded 24 nests of the species during transect surveys. Five dead individuals were also detected, cause of death looked like predation. In addition to gull colony, we observed 17 juvenile, 8 adult European shags with potential breeding on the cliff at southern part of the island. Five Alpine swifts were also observed (Table 23). We could not detect any nest of the species, but they probably nested in cracks and crevices on the island. No trace of mammals was observed on the island.

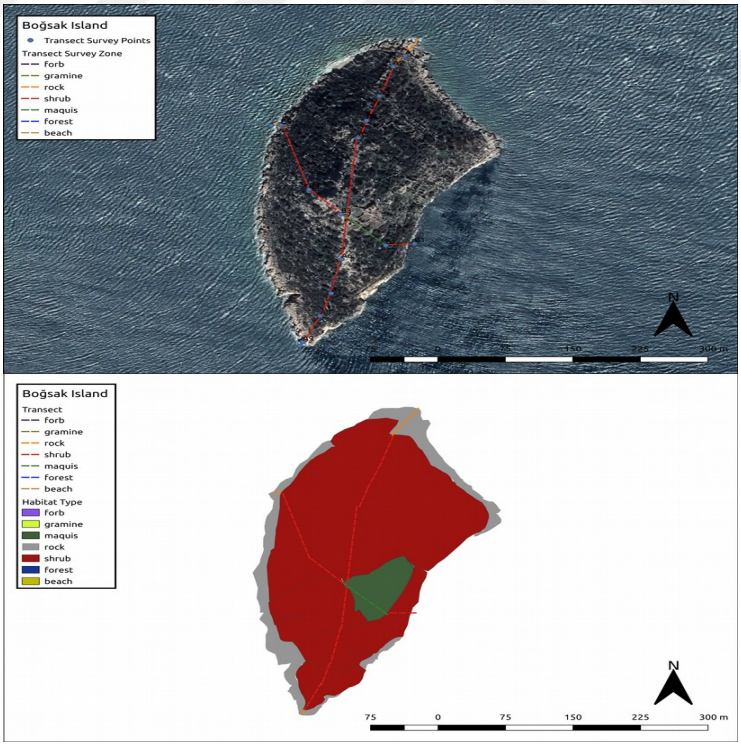

Figure 12 Satellite imagery and habitat map of Boğsak Island (I1)

Table 21 Habitat distribution on Boğsak Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Shrub	59296	79.6
Rock	10584	14.2
Maquis	4627	6.2

Table 22 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	51	3	7	0	Rock	0	NA
A2	47	10.5	11	2	Shrub	40-60	*Ptilostemon sp.*
A3	43	15.5	1	0	Shrub	40-60	*Olea europaea*
A4	30	16	0	0	Shrub	40-60	*Ptilostemon sp.*
A5	190	25	5	14	Shrub	20-40	*Ruta sp.*
A6	56	30	-8	3	Shrub	40-60	*Olea europaea*
A7	35	22.5	-11	0	Shrub	60-80	*Olea europaea*
A8	46	14	-12	0	Shrub	40-60	*Ptilostemon sp.*
A9	10	4.5	-64	0	Rock	0	NA
B1	34	7	24	0	Shrub	40-60	*Ptilostemon sp.*
B2	70	24	17	1	Maquis	60-80	*Olea europaeana*
B3	54	26.5	-16	2	Shrub	60-80	*Ptilostemon sp.*
B4	106	13	-7	2	Shrub	40-60	*Olea europaeana*
B5	9	3.5	-51	0	Rock	0	NA

Table 23 Bird species seen on transect survey on Boğsak Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**B1**	**B2**	**B3**	**B4**	**B5**	**Total**
European shag															25/ 12
Alpine swift															5/ 1
Ruddy shelduck															2/ 0
Yellow-legged gull		9/ 16			8/ 16										167/16

I2 Güvercin Island

Güvercin Island is a karst small island 234 m away from mainland. Two longest dimensions of the island 80 m and 67 m. on which transect survey was conducted. Area of island is 4421 m^2. Highest point of island is 9 m above sea level. Slope on the island was too low, almost none. Shrub is the dominant habitat type on the island.

The island hosted a Yellow-legged gull colony which consists of c.40 Yellow-legged Gulls; we detected only one nest during transect survey. We observed several gulls coming from the direction of Boğsak Island. No trace of mammals was observed on the island.

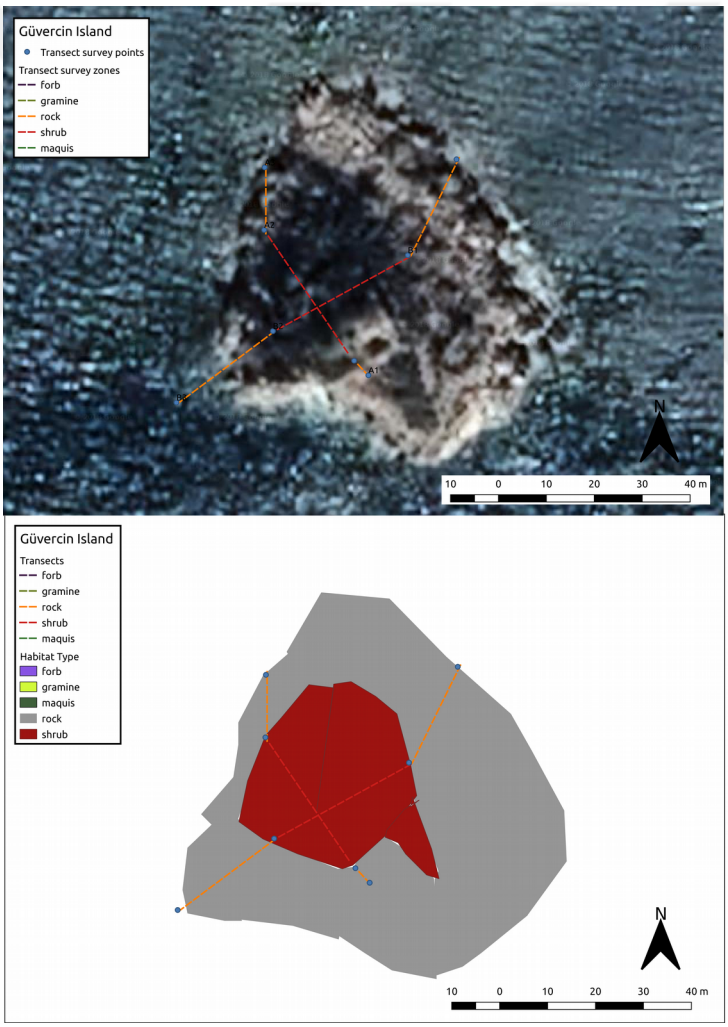

Figure 13 Satellite imagery and habitat map of Güvercin Island (I2)

Table 24 Habitat distribution on Güvercin Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	3335	75.43
Shrub	1086	24.57

Table 25 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	4	3.5	50	0	rock	0	NA
A2	29	4	-12	0	shrub	40-60	*Ptilostemon sp.*
A3	14	0.5	-4	0	rock	0	NA
B1	23	3.5	18	0	rock	0	NA
B2	33	8	3	1	shrub	40-60	Unidentified
B3	25	4.5	-21	0	rock	0	*NA*

Table 26 Bird species seen on transect survey on Güvercin Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**B1**	**B2**	**B3**	**B4**	**Total**
Alpine swift	40/16						40/ 16
Yellow-legged gull		9/ 16					40/ 16

I4 Dana Island

Dana Island is the biggest island on our survey area. It is 2262 m away from the mainland. Two axes of the island are 2695 m to 1338 m; area of island is 2680486 m^2. The highest point of the island 250 m above sea level. That island share many characteristics with mainland except for water source. Slope at southern and western parts of the island much higher compared to north side of it; there are cliffs on south and western shores. Due to its big size we did not do transects on the largest axes of the island, rather we did four transects which were perpendicular to longer axis of the island and we stopped at 75 m altitude. Shrubs and maquis observed near coast. A sparse red pine forest is the main characteristic of the island vegetation, it covers the hill on the island. We also observed sparse undergrowth in forest.

No marine bird colonies observed on the island, but we observed other bird species during transect surveys. Rüppell's Warbler, Blue Rock Thrush, Swift, Raven are those species, also we observed birds of prey, Elanora's Falcon was observed flying around the island. Goats were observed on hills and cliffs of island; that may alter vegetation of the island.

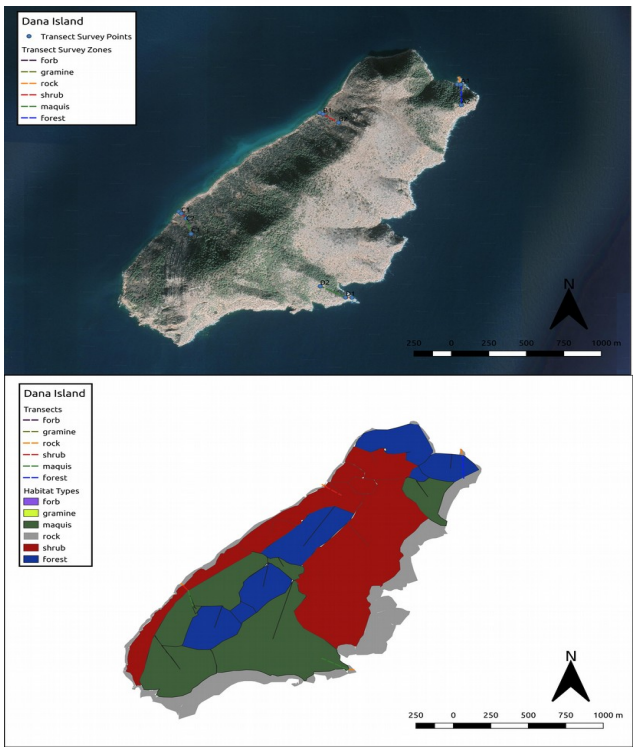

Figure 14 Satellite imagery and habitat map of Dana Island (I4)

Table 27 Habitat distribution on Dana Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Shrub	972832	36.29
Maquis	787500	29.38
Forest	499544	18.64
Rock	420610	15.69

Table 28 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	61	2	4	0	rock	0	NA
A2	172	40	24	0	forest	20-40	*Pinus brutia*
B1	26	6	25	0	rock	0	NA
B2	129	40	25	0	shrub	0-20	*Calicotome sp.*
C1	22	2	8	0	rock	0	NA
C2	53	7	8	0	shrub	0-20	*Cistus sp.*
C3	128	37	25	0	maquis	20-40	*Olea europaea*
D1	41	4	11	0	rock	0	NA
D2	194	23	9	0	maquis	20-40	*Pinus brutia*

Table 29 Bird species seen on transect survey on Dana Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**B1**	**B2**	**C1**	**C2**	**C3**	**D1**	**D2**	**Total**
Elanora’s falcon		1/1							1/1	2/1
Rüppelli’s warbler		1/2		2/2			1/2			4/2
Raven				1/ FO						1/FO
Yellow-legged gull				1/ FO						1/FO
Swift									50/1	50/1
Blue rock thrush									1/ 2	1/ 2

I5 Kösrelik Island

Kösrelik Island is 214 m away from the mainland. It covers 63511 m^2. Its longest axes are 521 m and 145 m; on which transect survey was conducted. Highest point of the island is 45 m above the sea level, there is a constant slope from beach to the cliff on the east side of the island. Mainly herbaceous annual plants, spiny shrubs and maquis observed. In addition to those, reeds are observed on some parts of island. High amount of rubbish indicates high human activity.

Three yellow-legged gulls were observed in nest defending behavior, but no nest were detected on island. We detected dense rabbit feces which indicate existence of a crowded rabbit population. Most probably high human activity and presence of rabbits turn that island unsuitable for breeding of marine birds.

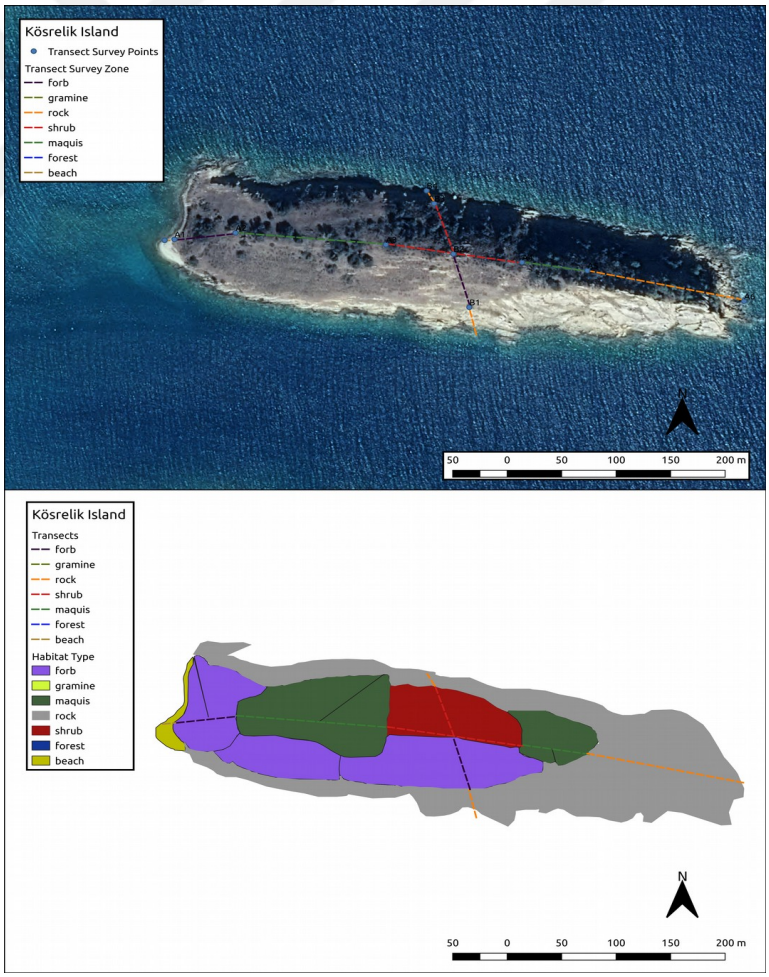

Figure 15 Satellite imagery and habitat map of Kösrelik Island (I5)

Table 30 Habitat distribution on Kösrelik Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	28983	45.63
Forb	15979	25.16
Maquis	12065	19.00
Shrub	5683	8.95
Beach	802	1.26

Table 31 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	12	0	0	0	beach	0	NA
A2	55	3	6	0	forb	60-80	*Arundo donax*
A3	139	18	10	0	maquis	0-20	*Olea europea*
A4	126	36	5	0	shrub	0-20	*Calicotome sp.*
A5	61	43	4	0	maquis	20-40	*Olea europea*
A6	148	23	-18	0	rock	0	NA
B1	29	1	4	0	rock	0	NA
B2	56	16	30	0	forb	60-80	*Arundo donax*
B3	54	19	-23	0	shrub	40-60	*Calicotome sp.*
B4	14	4.5	-40	0	rock	0	NA

Table 32 Bird species seen on transect survey on Kösrelik Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**Total**
Yellow-legged gull					3/2						3/2
Blackbird										1/1	1/1

I6 Major Beşparmak Island

Beşparmak Islands are two neighboring islands separated by a very narrow channel. Major Beşparmak Island is 540 m away from the mainland and covers 129837 m^2. Its two largest axes are 499 m and 450 m. The highest point is near to the center of the island and 107 m above the sea level. The slope is high in general and the west side of the island is a high cliff. The island is covered with rocky areas at low altitudes with sparse salt tolerant herbaceous vegetation. The island cover changes with increasing altitude; first to herbaceous vegetation, second to herbaceaous-bush vegetation and at last to maquis vegetation. Spiny bushes and maquis in general are the dominant vegetation of the island, in some parts of the island they get very dense and makes walking very difficult.

There are no marine bird colonies recorded on the island. We observed two yellow-legged gulls with territorial defense behavior, however, we did not observe any stronger breeding evidence during the transect surveys. Relatively diverse and rich terrestrial avifauna was observed in the island. Around 200 Alpine swifts were counted, they have nests in cracks in cliffs at western part of the island. We also observed blue rock thrush and rock nuthatch probably breeding in the island. We saw birds of prey frequently flying above the island that may indicate that the island is a proper preying area for those species. We observed high amount of rabbit feces on island, and saw a rabbit which indicates mammal presence in high numbers. A scuba diver vessel was seen near the island.

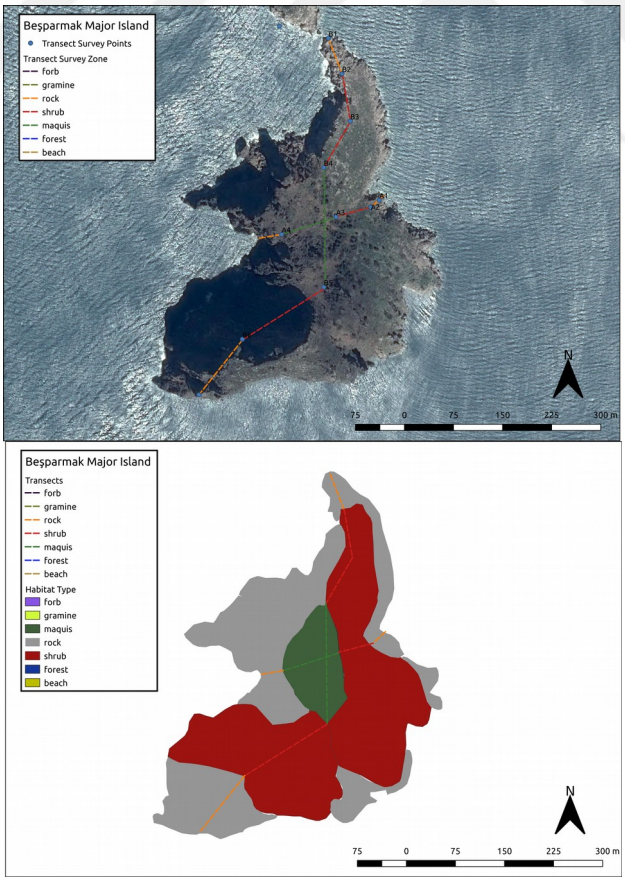

Figure 16 Satellite imagery and habitat map of Major Beşparmak Island (I6)

Table 33 Habitat distribution on Major Beşparmak Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Shrub	63994	49.27
Rock	54302	41.84
Maquis	11541	8.89

Table 34 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	26	5	23	0	rock	0	NA
A2	55	19	19	0	shrub	40-60	*Sarcopoterium sp.*
A3	89	42	18	0	maquis	20-40	*Olea europaea*
A4	36	28	-90	0	rock	0	NA
B1	60	4.5	9	0	rock	0	NA
B2	74	13	6	0	shrub	20-40	*Crithmum sp.*
B3	82	16	-1	0	shrub	60-80	Unidentified
B4	185	34.5	12	0	maquis	20-40	*Olea europaea*
B5	147	80	21	0	shrub	60-80	Unidentified
B6	107	53.5	-89	0	rock	0	NA

Table 35 Bird species seen on transect survey on Major Beşparmak Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**Total**
Blue rock thrush		1/2	1/2					1/1			3/2
Alpine swift			10/2	10/2	10/16			10/2	10/2	10/2	60/16
Rock nuthatch			1/2					1/2	1/2		3/2
Buzzard			1/FO					1/FO			2/FO
Peregrine								1/FO			2/FO
Yellow-legged gull											2/10

I7 Minor Beşparmak Island

Minor Beşparmak Island is 529 m far from the coast. Its area is 47944 m^2. Its two largest axes are 460 m and 153 m. It and highest point is 50 m above the sea level. There is a cliff on west side of the island. There is a doline very close to the center of the island connected to sea. We did three transects on that island, one is on the longest axis and two more perpendicular to is at south and north side of island. Vegetation on this island is denser than its neighbor. On coasts of the island shrubs were observed; towards to the center of the island plant coverage dominated by maquis type with plants higher than 2 meters.

There are no marine bird colonies recorded on the island. We recorded a yellow-legged gull flying around the island during transect surveys. There were Alpine swift nests on island, in addition to that we observed Blue rock thrush. A buzzard was flying above the island, but the most interesting record on the island was an eagle owl; presence on daytime on the island has suggested possibility of the nesting of the individual on the island but we could not detect the nest of it. We observed accumulated remains of Alpine Swifts, indicating that the Eagle owl was feeding on the Alpine Swift colony. No trace of mammals was found on the island.

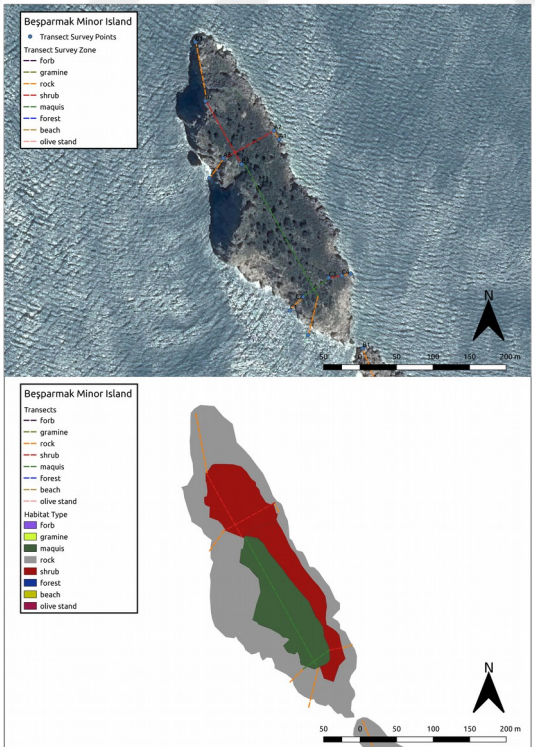

Figure 17 Satellite imagery and habitat map of Minor Beşparmak Island (I7)

Table 36 Habitat distribution on Minor Beşparmak Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	25840	53.90
Shrub	12249	25.55
Maquis	9855	20.55

Table 37 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	13	2	18	0	rock	0	NA
A2	80	27	35	0	shrub	60-80	*Sarcopoterium sp.*
A3	34	25	-90	0	rock	0	NA
B1	82	16	23	0	rock	0	NA
B2	99	35	3	0	shrub	40-60	*Sarcopoterium sp.*
B3	205	33	-3	0	maquis	40-60	*Olea europea*
B4	54	14	-31	0	rock	0	NA
C1	25	14	-90	0	rock	0	NA
C2	44	22.5	-14	0	maquis	60-80	*Olea europea*
C3	18	16	-6	0	shrub	60-80	*Sarcopoterium sp.*
C4	13	7.5	-90	0	rock	0	NA

Table 38 Bird species seen on transect survey on Minor Beşparmak Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	C3	**C4**	**Total**
Buzzard		1/ FO										1/FO
Yellow-legged gull		1/1										1/1
Blue rock thrush		1/2										1/2
Alpine swift			10/2	5/16						2/16		17/16
Eagle owl						1/1						1/1

I8 Yılanlı Island

Yılanlı Island is the one of the farthest islands to the mainland in the region, with a distance of 1785 meters to mainland. Area of the island is 9285 m2. Its longest axes are 180m and 114m on which transect survey was conducted. The island rises like a wall on sea, with maximum height of 17 m. Coasts of the island are rocky with high sloop, a sparse biannual plant and grass vegetation observed among rocks. South side of the island is a cliff. Top of the island is a plain covered mostly with grass and moderate shrub.

One of the most dense marine bird breeding colonies were observed on that island. We counted 40 Yellow-legged gull and 16 Audouin's gull individuals on island. We detected 16 gull nests during transect survey. 10 of them was on northern wall of the island. That area is the only location we have detected breeding Audouin's gulls during 2016 survey. We also observe high mortality in Audouin's gull chicks. In addition to gull colonies, European shags might be breeding on cliffs of the island juveniles were detected. Also, high number of Alpine Swift was counted. No trace of mammals was observed on the island, but high amount of litter and presence of a shack indicate intense human presence and use on island.

In 2017 and 2018 surveys we could not detect Audouin's gull on the island. Only Yellow-legged gulls were breeding on the island.

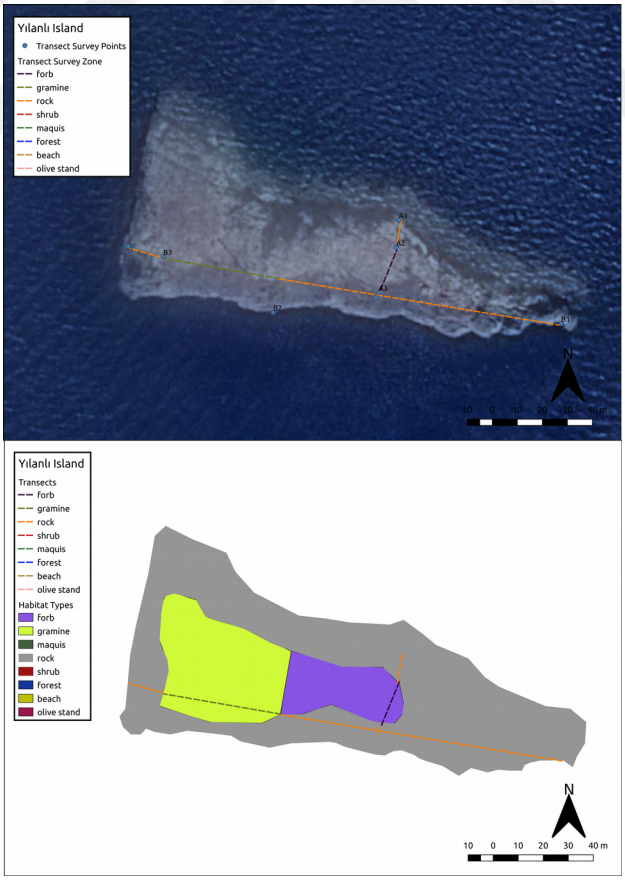

Figure 18 Satellite imagery and habitat map of Yılanlı Island (I8)

Table 39 Habitat distribution on Yılanlı Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	6372	68.63
grass	1959	21.09
Forb	954	10.28

Table 40 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	12	4	42	0	rock	0	NA
A2	19	12.5	28	5	forb	60-80	*Chenopodium sp.*
A3	3	8.5	-45	0	rock	0	NA
B1	115	7	7	1	rock	0	NA
B2	47	15.25	3	10	grass	0-10	Unidentified grass
B3	14	8.25	-62	0	rock	0	NA

Table 41 Bird species seen on transect survey on Yılanlı Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**Total**
Audouin’s gull							8/16
Yellow-legged gull				1/12	3/12		34/16
Alpine swift				1/16			>100/16
European shag							2/16

I9 Yelkenli Island

Yelkenli Island is just 32 m away from the mainland. Area of the island is 12371 m^2. It is a round shaped island with the longest dimensions of 122m and 90m. The island has very sparse vegetation as shrubs, it is almost like bare rock. The highest point is 12 m above sea level. Western coasts of island look like go underwater with tidal changes.

We counted four Audouin's gull and a Yellow-legged gull on island, but they did not show territorial behavior, and we did not detect any nest on the island. Alpine swifts were observed flying above the island, but there is not suitable place for nesting for the species on the island. No mammal trace was found.

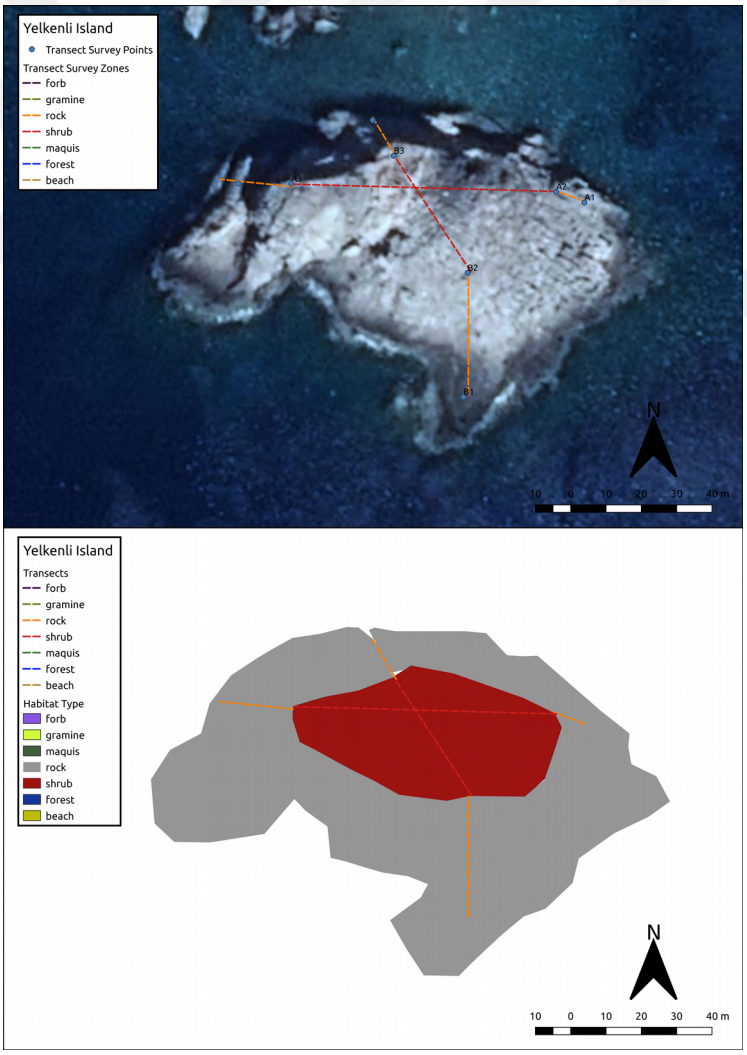

Figure 19 Satellite imagery and habitat map of Yelkenli Island (I9)

Table 42 Habitat distribution on Yelkenli Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	10305	83.30
Shrub	2066	16.70

Table 43 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	9	2	26	0	rock	0	NA
A2	74	4	0	0	shrub	20-40	*Chenopodium sp.*
A3	21	2	-11	0	rock	0	NA
B1	34	1.5	5	0	rock	0	NA
B2	39	7.5	13	0	shrub	20-40	*Chenopodium sp.*
B3	13	6	-90	0	rock	0	NA

Table 44 Bird species seen on transect survey on Yelkenli Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**Total**
Audouin’s gull							4/1
Yellow-legged gull							1/1
Alpine swift							2/1

I10 Minor Aydıncık Island

Minor Aydıncık Island is the smaller of the two neighboring isles at Aydıncık offshore. It is 638 m away from the mainland. Area of the island is 11975 m^2. It is an oval shaped island with axes 125 m and 81m. The highest point is 4 m above sea level. Coasts of the island are rocky with a low slope. A moderate shrub cover was observed on middle part of the island.

In 2016 survey, 25 Yellow-legged gull and 10 European shags were counted flying above the island. Three of the shags were juvenile. 11 Yellow-legged gull nests were observed on island, eight of them was on area with shrub vegetation. No trace of mammals were observed on the island.
An angler was fishing on the island.

In 2017 survey we counted 20 adult Audouin's gull individual flying above the island and showing terrestrial behavior. We detected 7 Audouin's gull nests on south-west shore of the island; we counted 16 chicks. In 2018 survey Audouin's gull breeding colony which has 15 individuals was on the same region of the island.

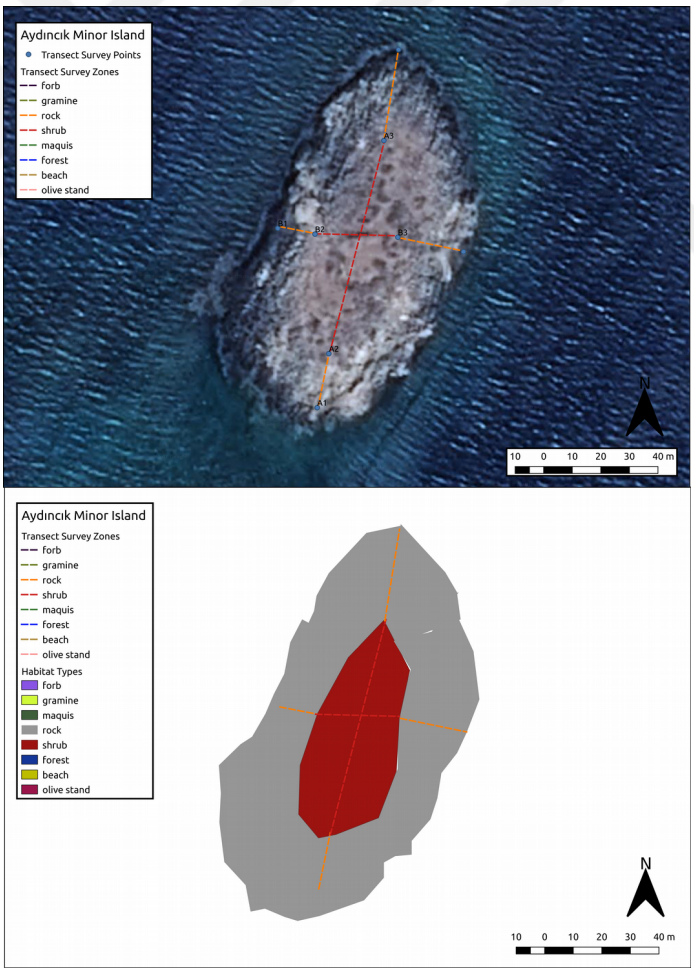

Figure 20 Satellite imagery and habitat map of Minor Aydıncık Island (I10)

Table 45 Habitat distribution on Aydıncık Minor Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	10094	84.30
Shrub	1880	15.70

Table 46 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	20	1	6	0	rock	0	NA
A2	78	2	0	8	shrub	20-40	Unidentified
A3	33	1	-3	0	rock	0	NA
B1	13	2	18	0	rock	0	NA
B2	29	3.75	-1	3	shrub	20-40	Unidentified
B3	24	1.75	-8	0	rock	0	NA

Table 47 Bird species seen on transect survey on Aydıncık Minor Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**Total**
Yellow-legged gull					1/12		36/12
European shag							7/12
Little egret							12/0

I11 Major Aydıncık Island

Major Aydıncık Island is 800 meters away from the mainland. Its area is 24851 m^2. longest dimensions are 254 and 128 meters. Highest point is 26 m at the southern part of the island, and it ends with a cliff which has a crack on it. We did two transects on island and observed sparse shrub and maquis vegetation on island.

We counted 50 Yellow-legged gull individuals flying above both islands. We detected four gull nests during transect survey. Also, the cliff on the south side is a suitable site for European shag breeding. We also detect Alpine swift nests in cracks on the highest point of the island. Presence of high number of rabbits and traces of high human activity is observed on island.

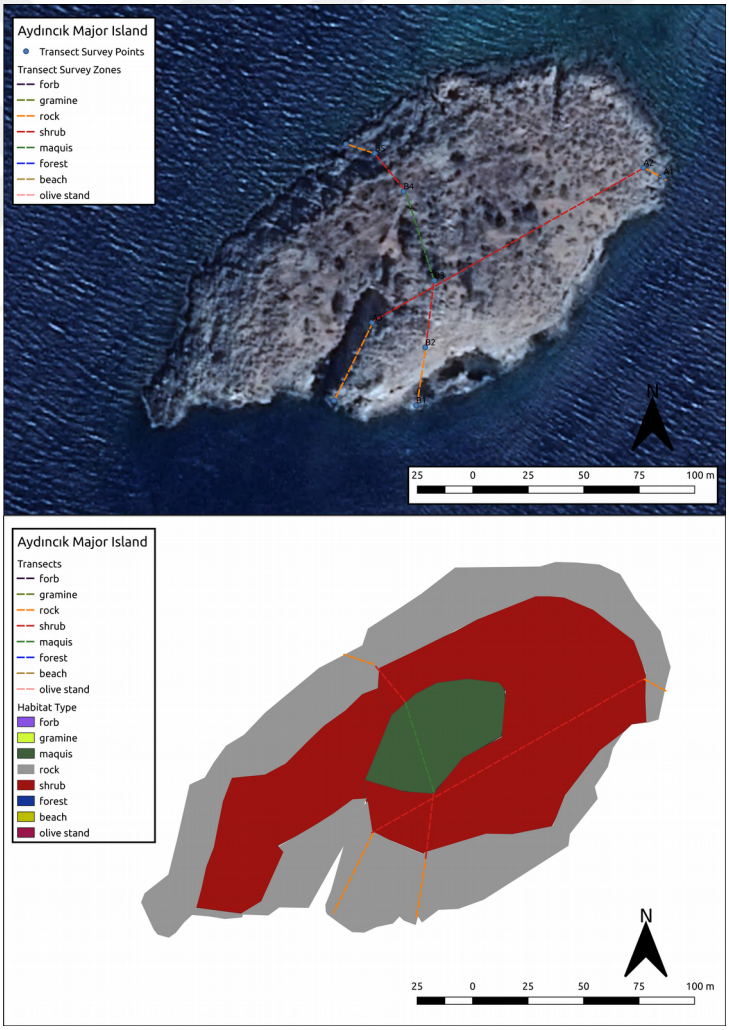

Figure 21 Satellite imagery and habitat map of Major Aydıncık Island (I11)

Table 48 Habitat distribution on Aydıncık Major Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Shrub	11836	47.63
Rock	10815	43.52
Maquis	2200	8.85

Table 49 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	11	3	33	0	rock	0	NA
A2	140	16	8	4	shrub	20-40	Unidentified
A3	40	13	-41	0	rock	20-40	Unidentified
B1	26	5	23	0	rock	0	NA
B2	30	17.5	30	0	shrub	20-40	Unidentified
B3	42	20	-14	0	maquis	0-20	*Olea europea*
B4	20	10	-30	0	shrub	20-40	Unidentified
B5	14	2.5	-21	0	rock	0	NA

Table 50 Bird species seen on transect survey on Aydıncık Major Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**B5**	**Total**
Yellow-legged gull		1/12							51/12
Alpine swift					1/16				1/16

I12 Bozyazı Island

Bozyazı Island is 197 meters away from mainland, very close to city center. Area of the island is 11794 m^2. Its axes are 45 m and 100 m. Its highest point is 16 m above sea level. Human use and impact on island is clearly seen, there is an old olive stand on the island. Maquis and shrubs are other vegetation types on the island.

We counted 17 Yellow-legged gull individuals flying around island, but only two of them showed territorial behavior. There was not any nest or chicks. Hooded crow is another bird species we have detected on the island. High number of rabbits were present on the island.

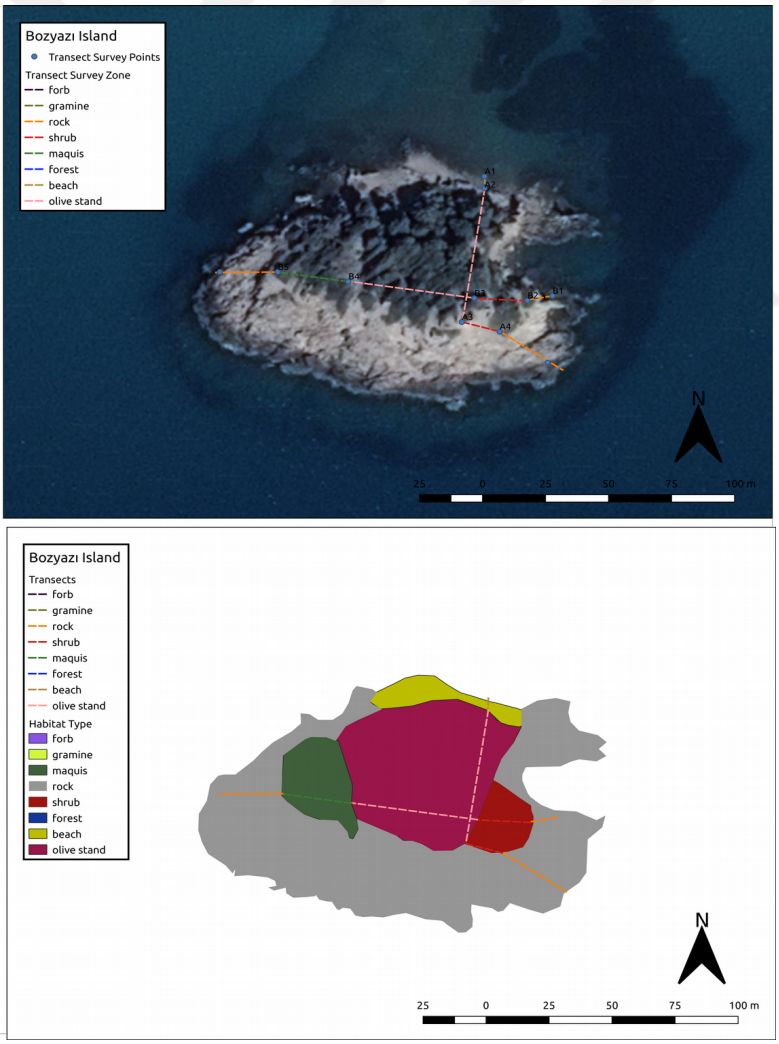

Figure 22 Satellite imagery and habitat map of Bozyazı Island (I12)

Table 51 Habitat distribution on Bozyazı Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	6713	56.91
Olive Stand	3228	27.37
Maquis	861	7.30
Shrub	538	4.56
Beach	454	3.85

Table 52 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	5	0.5	12	0	beach	0	NA
A2	57	8.5	15	0	olive stand	80-100	*Olea europea*
A3	16	9.5	-54	0	shrub	0-20	*Myrtus communis*
A4	29	1.5	-6	0	rock	0	NA
B1	10	3.5	55	0	rock	0	NA
B2	21	11	22	0	shrub	40-60	*Myrtus communis*
B3	50	13.5	-3	0	olive stand	80-100	*Olea europea*
B4	28	10	-8	0	maquis	40-60	*Laurus sp.*
B5	25	4	-19	0	rock	0	

Table 53 Bird species seen on transect survey on Bozyazı Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**B5**	**Total**
Yellow-legged gull										17/12
Hooded crow		2/1								2/1

I13 Mamure Island

Mamure Island is 297 meters away from mainland. Area of the island is 2031 m^2. Its axes are 43 m and 41 m. Slope on the island is not very high, the highest point is 6 m above sea level. Island is mostly bare rock except for middle of the island which is covered by biannual herbaceous plants moderately. Also, eutrophic tidal ponds cover large area on the island.

40 adult, 25 juvenile Yellow-legged gull individuals were counted on island, most of the juveniles were able to fly on 30th of May. In addition to gulls, a European shag was seen on the island. Four gull nests were detected on transect survey. We have detected dead birds of different species (gull, European shag, egret) with traces of predation. No mammal presence was detected on island.

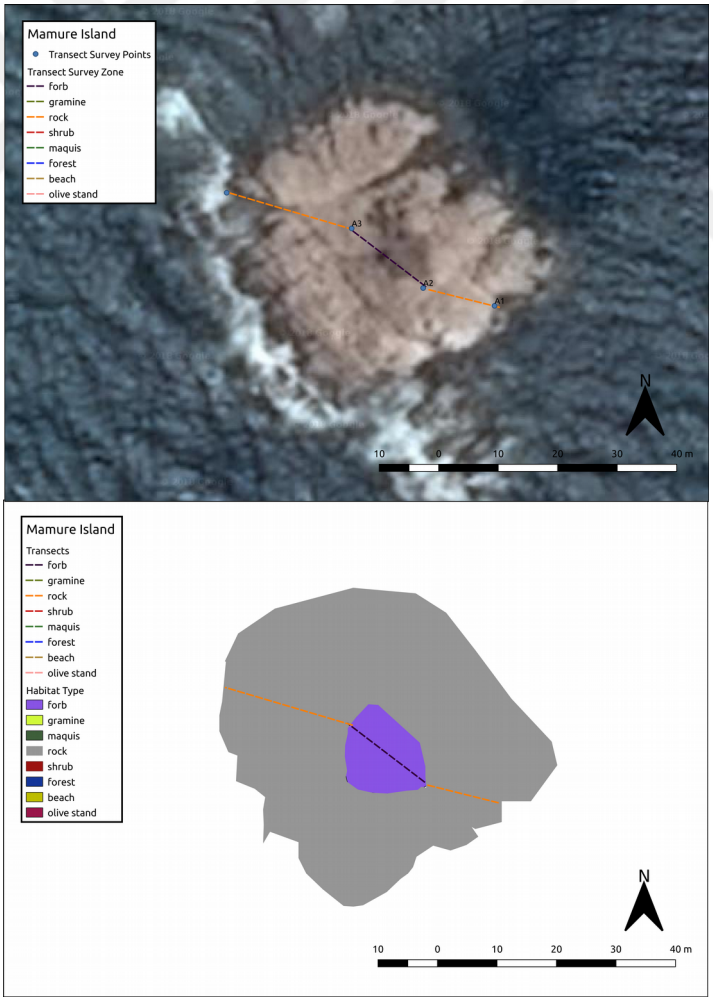

Figure 23 Satellite imagery and habitat map of Mamure Island (I13)

Table 54 Habitat distribution on Mamure Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	1865	91.83
Forb	166	8.17

Table 55 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	13	2.75	25	0	rock	0	NA
A2	16	5.25	-2	1	forb	60-80	*Malva sp.*
A3	22	2.5	-13	3	rock	0	*NA*

Table 56 Bird species seen on transect survey on Mamure Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**Total**
Yellow-legged gull				40/12
European shag				1/1

I14 Yalcılı Island

Yalcılı Island is one of the closest islands to the mainland in the survey area; distance from mainland is 47 m. Its axes are 88 m and 71 m; area of the island is 5123 m^2. The island has a very high slope, highest point is 29 m above sea level, west side is a cliff. Vegetation on the island is maquis dominated and very dense. It was hard to move on the island, being cautious and having some experience on climbing is really important.

Three Yellow-legged gulls were recorded flying above the island, but they did not show territorial behavior. More than 100 Alpine swifts were counted flying above island, we have detected two Alpine swift nests during transect survey.

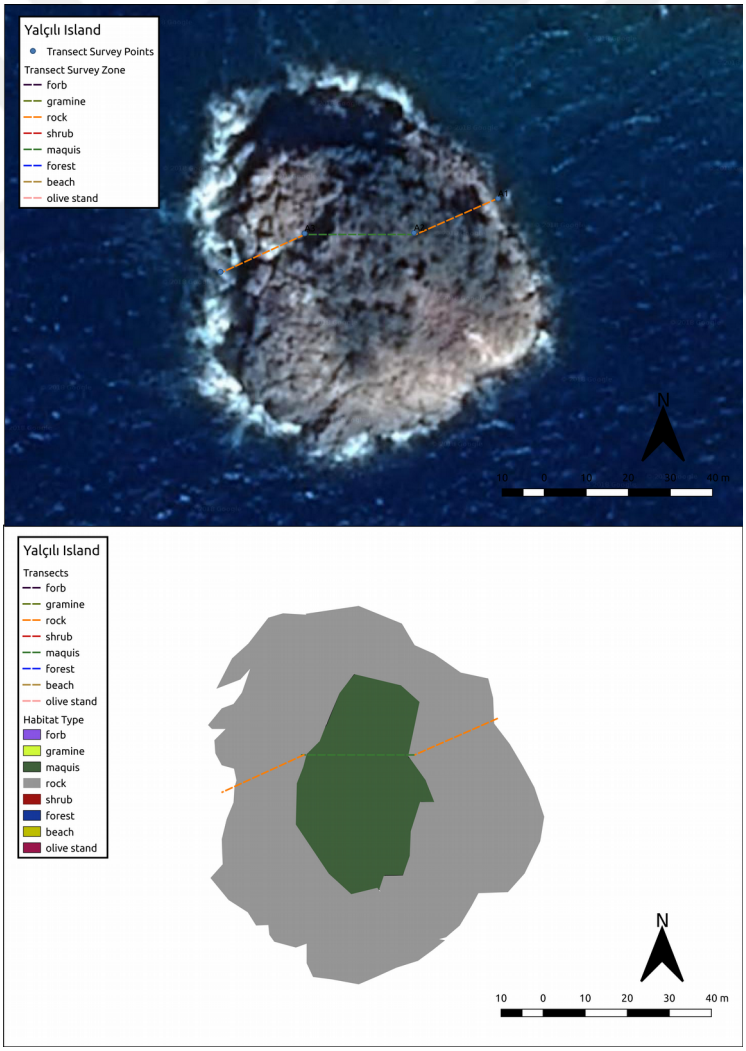

Figure 24 Satellite imagery and habitat map of Yalçılı Island (I14)

Table 57 Habitat distribution on Yalçılı Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	3931	76.73
Maquis	1192	23.27

Table 58 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	21	7.5	46	0	rock	0	NA
A2	27	22	31	0	maquis	40-60	*Olea europea*
A3	21	14.5	-90	0	rock	0	*NA*

Table 59 Bird species seen on transect survey on Yalçılı Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**Total**
Yellow-legged gull				3/1
Alpine swift	2/16		2/16	4/16

I21 Aksaz Island

Aksaz Island is 2592 m away from mainland. Its area is 3268 m^2. Its widest dimensions are 70 m and 52 m. Highest point of the island is 12 m above sea level and slope on island is high. Island is mostly bare rock, but sparse biannual vegetation observed in some parts.

25 Yellow-legged gull, 25 European shag were flying above the island. We detected two gull and three European shag nests in transect survey. Ten Alpine swift were also seen on island, we detected Alpine swift nests in cracks on rocks. No human effect was observed on island, also no mammal presence was detected.

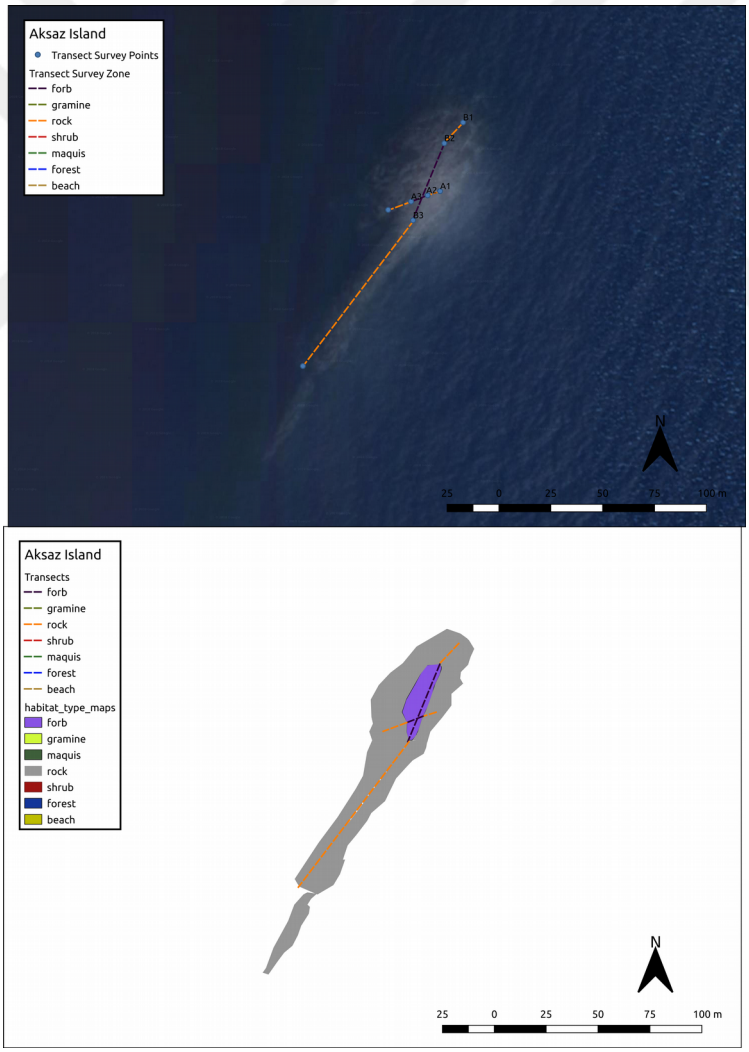

Figure 25 Satellite imagery and habitat map of Aksaz Island (I21)

Table 60 Habitat distribution on Aksaz Island. Total area of habitat types are estimated by using transect survey data and air photograph.

Habitat Type	**Area (m^2)**	**Percentage**
Rock	2942	90.03
Forb	326	9.97

Table 61 Details of parts of transect paths. Each path represents an area with different habitat characteristics.

Path	**Length (m)**	**Mean Altitude (m)**	**Slope (°)**	**Nest**	**Habitat Type**	**Vegetation closeness (%)**	**Dominant Plant**
A1	6	3	72	0	rock	0	NA
A2	9	9	42	0	forb	20-40	*Mal va sp.*
A3	12	6	-77	0	rock	0	NA
B1	14	1	8	0	rock	0	NA
B2	88	6	-7	2	forb	20-40	*Malva sp.*
B3	40	5	12	0	rock	0	NA

Table 62 Bird species seen on transect survey on Aksaz Island, first number in the cells indicates number of individuals, second number shows highest breeding code of the species observed on the island. Birds flying above the island are represented on “Total” column.

Species	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**Total**
Yellow-legged gull					1/12		26/12
European shag							28/13
Alpine swift					1/16		1/16

I3 Güvercin Islet

Güvercin Islet is a small karst island 22 m away from the mainland and covers just 234 m^2 with two longest axes of 26 m and 15 m. Which could be considered as rocks rather than an island. There is no vegetation on that island and no bird colony was detected. We did not land on it.

I15 Çıpçılı Island

Çıpçılı Island is a small islet 165 m away from the mainland. Area of the island is 2042 m^2. Longest axes are 62 m and 56 m. All coasts of the islet are cliffs, top of the island is around 16 meters and covered with shrub. Due to its small size, steepness of cliffs we did not land on this Island

No bird activity was observed on the island.

I16 Kalaytaşı Island

Kalaytaşı Island is very close to the mainland with distance of 12 m. Area of the island is 3297 m^2. The island is covered with bare rock. We did not land on this island.

No bird activity was observed on the island.

I17 Kurt Island

Kurt Island is 352 m away from the mainland, its area is 2862 m^2. Island is nearly triangular shape with cliffs on three sites. We did not land on this island. Top of the island is covered by reeds.

We have counted 50 Alpine swifts flying above the island, they were nesting on cliffs of the island.

I18 Doğanlı Island

Doğanlı Island is only 16 m away from the mainland and its area is 731 m^2. All coasts of the island are cliff, there is sparse herbaceous vegetation on south-east site of the island. We did not land on the island.

Around 40 Alpine swift were counted. Also we saw a Peregrine falcon flying above the island.

I19 Ilısu Island

Ilısu Island is 219 m away from the mainland, its area is 864 m^2. The island is covered by bare rock. We did not land on the island.

No bird activity was observed on the island.

I20 Kuzu Islet

Kuzu Islet is a small islet 54 m away from the mainland, covers 689 m^2. There is no vegetation on the islet. We did not land on the islet.

No bird activity was observed on the islet.

3.3 Effects of Mammal Presence on Habitat and Marine Birds

Invasive mammals were detected on 5 out of 14 visited islands. A noticeably high nest density was observed on the islands without mammals (Figure 26), but Wilcoxon Rank Sum Test did not attain statistical significance (W = 34, p-value = 0.1173), that might be due to low sample size.

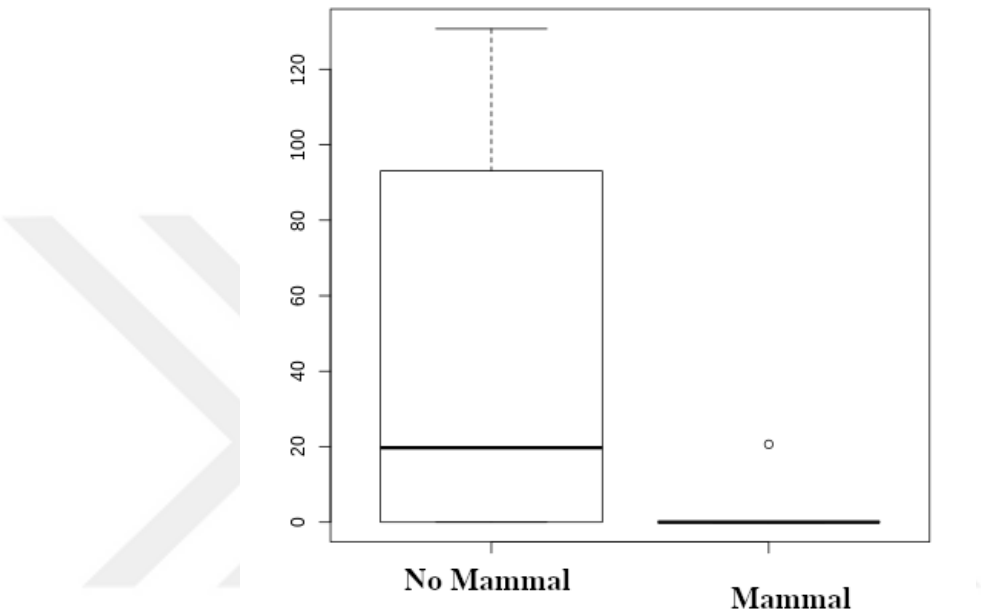

Figure 26 Nest density distribution on islands without mammals (left), and with mammals (right)

Rabbits (Family: Leporidae) and domestic goats (*Capra aegagrus hircus*) were the invasive mammals observed on islands; relationship between vegetation type (Table 63) and grazing pressure was also examined. Wilcoxon Rank Sum test was applied in order to see effect of mammal presence on herbaceous plant coverage on island, the test has failed to reject null hypothesis (W = 25, p-value = 0.7384), there is no significant effect of mammal presence on vegetation type.

Table 63 percentage of herbaceous plant coverage on islands and its relation with mammal presence

Island	No cover	Woody	Annual-biannual	Mammal
1	14.21	85.79	0	0
2	75.43	24.57	0	0
4	15.69	84.31	0	1
5	46.89	27.95	25.16	1
6	41.82	58.18	0	1
7	53.90	46.11	0	0
8	68.63	0	31.37	0
9	83.3	16.70	0	0
10	84.3	15.70	0	0
11	43.52	56.48	0	1
12	60.76	39.23	0	1
13	91.83	0	8.17	0
14	76.73	23.27	0	0
21	90.03	0	9.97	0

3.4 Genetic Structure of Audouin's gull

3.4.1 DNA Extraction from the Samples

Results of DNA extraction could be seen in Table 64.

Table 64 Concentration of DNA and quality. Letter codes are A: *L.audouinii*- Turkey-2016; B: *L.michahellis*-Turkey-2016; C: *L.audounii*-Spain-2016; D: *L.audouinii*-Cyprus-2017; E: *L.audouinii*-Turkey-2017

Code	Concentration (ng/µL)	260/280	260/230
A8	294.95	1.97	2.17
A19	77.19	2.01	2.60
A20	252.09	2.04	2.30
A21	105.5	2.02	1.82
A23	95.82	2.04	2.52
A24	46.53	1.94	2.42
A25	18.72	1.77	2.34
A26	38.15	1.85	1.39
A31	42.23	1.81	1.55
B3	254.49	2.05	2.39
B5	147.06	2.07	2.46
B6	115.51	2.06	2.34
B11	71.75	2.03	2.26
B15	67.62	2.02	2.52
B16	79.19	1.94	2.10
B17	237.53	2.05	2.35
B18	135.91	1.94	2.23
B22	65.19	2.01	2.66
B24	18.96	1.94	3.16
C1	554.80	1.85	2.43
C2	1638.40	1.82	2.40
C3	1175.30	1.84	2.38
C4	27.93	1.78	3.32
C5	49.42	1.83	3.06
C6	868.90	1.83	2.47
C7	951.0	1.79	2.45
C8	171.5	1.65	2.14

Table 64 continues			
C9	364.2	1.87	2.47
C10	1577.1	1.81	2.48
C11	655.2	1.76	2.38
C12	144.40	1.89	2.70
C13	771.1	1.84	2.62
C14	37.8	1.74	3.28
D1	86.85	2.16	0.36
D2	141.53	3.00	2.13
D3	50.62	1.98	2.28
D4	105.16	1.94	2.46
D5	41.29	1.92	2.89
D6	81.53	2.02	2.29
D7	158.14	2.09	2.25
D8	85.99	1.90	2.08
D9	102.46	1.96	2.13
E1	93.01	1.98	3.25
E2	292.16	2.02	2.27
E3	1065.48	2.03	2.36
E4	115.48	2.04	2.35
E5	79.32	2.02	2.08
E6	276.65	2.03	2.27
E7	1579.86	1.67	2.19
E8	465.18	1.98	2.25
E9	71.82	2.02	2.39
E10	301.23	2.06	2.14
E11	121.46	2.05	2.20
E12	231.34	1.98	2.15
E13	871.72	1.95	2.47
E15	396.87	2.04	2.14
E16	239.69	2.00	2.24

3.4.2 Gene Amplification

PCR success is quite low (18 successful in 57 samples) in amplification trials conducted by using ThermoFisher PCR Kit; that might be caused by low quality of the DNA. A product of c. 1400 bp has contain the locus of interest. A c. 600 bp non-specific band formation was observed during optimization process of amplification, but that band is eliminated by using finalized PCR conditions (Table 7).

3.4.3 Sequencing and Alignment

Sequencing of B17 sample was tried three times in two sessions, but in all sequencing efforts quality of readings were too low, so that sample is excluded from analysis. Sequence information of C2,C4, C6, C7, C8,C9, C10, C12, C13, D7, D8, D9, E4, E5, E6,E10, E15 are used in analyses. Reads of c. 1100 bp long part for each sample are obtained; 656 base pairs part of the control region has been obtained after trimming of mismatched end parts. Variation in the region is much lower than expected, only 6 sites in 656 bp region showed variability, they are most probably due to sequencing error; those sites are distributed randomly. Distance score between individuals is 0. Only one haplotype has been observed in all populations. BLAST (Query ID: lcl|Query_216173) is done for the sequence and it gives max score of 970 with *Larus relictus,* with 96% identification. Sequence obtained is matched with the region started from 15789th base of *L.relictus* mtDNA sequence (Seq. ID: KC760146.1).

3.4.4 Phylogenetic Analysis

Overall mean distance between 99 aligned sequences have been estimated as 0.07. Distance score between samples of our study is 0 as previously mentioned. The most close sequence is *L.relictus* which is 0.11 to the samples of *L.audouinii.* Phylogenetic tree with maximum log likelihood (-29096.52) suggests close relationship between *L.relictus* and *L.audouinii*. (figure 27) But, other Larus species are at depicted far branches.

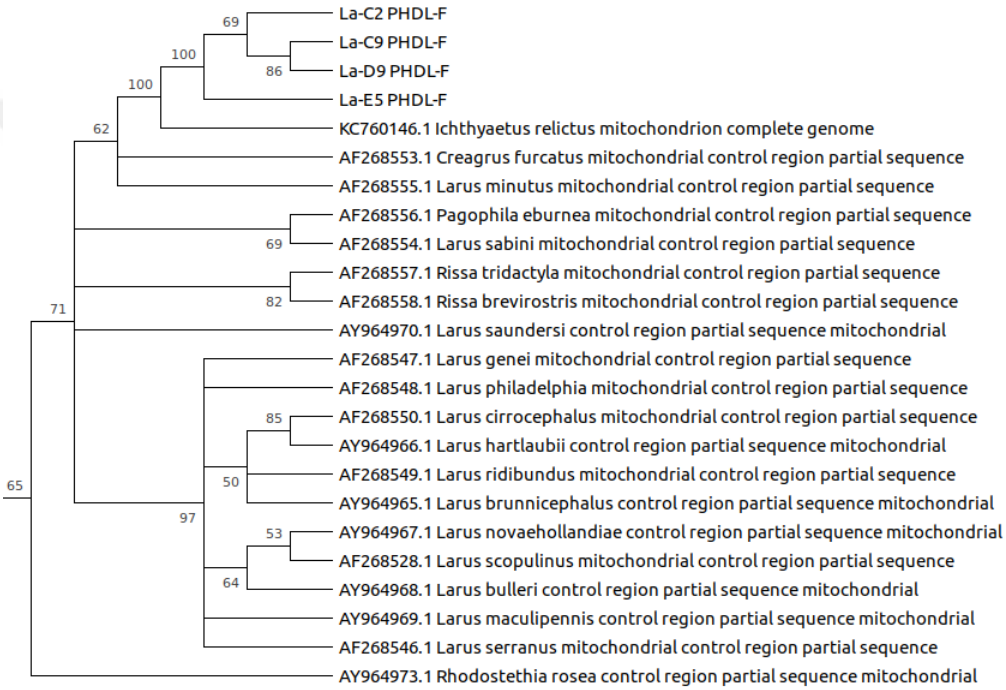

Figure 27 Phylogenetic tree constructed by Maximum Likelihood after 500 bootstraps. Samples sequenced is this study are the individuals with “La” code. Bootstrap scores are represented on branches. Due to limitation of space only monophyletic group of L.audouinii samples of this study is represented.

4-DISCUSSION

Marine ecosystems are under threat due to human activities. Effects of anthropogenic climate change could be detected in all oceans of the world (Barnett *et al.*, 2001), and that rapid change in conditions of marine environment is causing irreversible shifts in marine ecosystems (Hoegh-Guldberg & Bruno, 2010). Human activities such as transportation, energy production, exploitation of food sources cause destruction and pollution of coastal and estuarine ecosystems (Kennish, 2002). Plastic debris could be detected even the most remote parts of the marine environment (Law, 2017), and have negative effects on marine ecosystems (Vince & Hardesty, 2017). Accumulation of heavy metal and organochlorines such as DDT in marine environment and and organisms is another major threat to marine ecosystems; pollution level is high especially in bays and estuaries which are in close proximity to crowded and industrialized regions, and have input from major rivers (Fowler, 1990). The level of those threats and human related changes are so high that, the signature of the human species on the Earth has become persistent especially after Industrial Revolution. Due to that situation it has been suggested that the epoch in which the human species thrive should be named Anthropocene (Waters *et al.*, 2016), but keep going in this behavior might end this epoch with a mass extinction (Ripple *et al.*, 2017).

Understanding human caused disturbance in environment and level of their effect on ecosystems have great importance to reduce the impacts of human on the Earth, and prevent rapid mass extinction. A holistic approach which considers physical, biological properties of the environment and features of human activities, and use power of observations and modeling together is required for management of human activities and protection of ecosystems; physical and biological indicators has great importance in this process (Botsford *et al.*, 1997). Marine birds are important indicators of the level of anthropogenic pressure, and health of marine ecosystem. High trophic level of the group make populations prone to be affected by bottom up processes; in addition to that, breeding success parameters such as clutch size, and survival are depended on ecosystem status and food availability (Piatt *et al.*, 2007). marine birds are large animals which could be easily spotted and traced, their colonial breeding behavior allows tracking many individuals with less effort; there

have been long term monitoring studies, so there is a high amount of knowledge on their life history, physiology and behavioral properties (Furness & Camphuysen, 1997). There are many studies on which marine birds are used as sentinels of climate change and oscillation events. A long term monitoring study which covers 33 years data between 1955-1987 and response of the marine species from four different trophic levels revealed that marine bird breeding success responses are parallel to climatic variables and response of the lower trophic levels to the change (Aebischer *et al.*, 1990). This results show that marine birds are reliable bio-indicators to monitor changes in physical environment and in lower trophic levels. Monitoring of marine bird breeding is easier, requires less cost and energy compared to monitoring other marine organisms; all these properties make marine birds efficient bio-indicators in order to assess ecosystem health and anthropogenic pressure on environment.

Marine birds could be categorized into two groups according to their role as an indicator. Firstly they could be sentinels of the ecosystem health and level of pollution and climate change; secondly observations on them could be used to evaluate quantity of other components of ecosystem, like in the case of fish stock assessment (Piatt *et al.*, 2007). Although they are good indicators due to the advantages previously stated; there are key points to be considered in order to have reliable assessments and predictions; otherwise, a wrong diagnosis could lead inefficient management of ecosystems, and wrong actions may cause harmful effects on ecosystem health (Parsons *et al.*, 2008). Having long term monitoring data for several species from different regions, and combining these data while developing indexes, statistics and models are very important to have reliable assessments (Frederiksen *et al.*, 2007). Another important property of a bio-indicator taxon is its sensitivity and response capability to the variable which will be used as a proxy in the assessment (Furness & Greenwood, 1993). Therefore, having a strong background knowledge on physiology, trophic interactions and behavior of the species used as an indicator has a great importance. If data sets and prior knowledge on indicators are adequate, than the aim of the assessment should be decided on the next step. Marine bird indicators could be used to evaluate status of the marine birds for their own health, or health of marine ecosystem. Stock assessment studies could also be done by using marine birds as indicators; parameter choice, decision on focus species should be done accordingly (Parsons *et al.*, 2008). Unfortunately there has

not been any monitoring study in the southeast coasts of Anatolia whose focus is marine bird populations. The last counting on breeding marine bird populations in the region was done in 2003 by Çağlayan; whose focus was not the all marine bird populations, but only *L.audouinii*, and the fieldwork was confined only on Aydıncık Islands (Çağlayan, 2003). There is a huge gap of knowledge in status of the breeding marine bird populations in the region. In this study, bird counts and habitat surveys were conducted on all possible breeding sites. Size of breeding colonies and nest numbers were recorded. Habitat characteristics of the islands were defined by standardized methods and relationship between nest number and habitat type evaluated.

We have detected eight Yellow-legged Gull colony (150-200 pairs), three European Shag colony (7-15 pairs) and only one Audouin's gull colony in the region (6-10 pairs). In 2017 and 2018 surveys conducted on Yılanlı, Minor and Major Aydıncık Islands three Yellow-legged gull breeding colony and one Audouin's gull breeding colony have been recorded. Nesting site of Audouin's gull colony have been moved to Minor Aydıncık Island. In 2017 the size of theAudouin's gull colony has been increased to 10 pairs. When those numbers are considered with the size of the research area and foraging behavior of marine birds; total population size estimations to be 150-250 pairs for Yellow-legged gull, 10-20 pairs for European shag and 8-10 pairs for Audouin's gull. Number of European shag colonies and population size may be higher, because breeding site of the species is not only isolated islands, but cliffs on mainland too (Heubeck *et al.*, 2015). We have observed cracks with trace of discarded guano on cliffs during cruising, but we have not include that observations to analyses due to lack of details on vegetation, and area data from the sites. Eight of 21 islands had breeding colonies, 62 gull nests were detected on transect surveys. Eggs and chicks of different age groups are observed in or nearby those nests. High number of dead chicks were recorded on Audouin's gull breeding site. Presence of eggs at the end of May suggests a possible failure in breeding and retrial. A notable relationship between nest density and habitat type is observed on colony hosting islands. Very high density of nests on grass and forb vegetation is obvious. Nest density on areas covered with herbaceous plants is significantly higher than areas with woody plants or areas without any plant coverage. Mammal presence seems also cause an important difference between nest densities on islands, but this effect could

not be seen in statistical tests due to small sample size. Human presence on some islands were also observed. Although it is too early to use marine birds as bio-indicators in the region, this study would form a basis for long term monitoring studies, which are the key requirement for reliable assessment of ecosystem health.

Proximity to foraging areas and isolation from predators are two key properties of marine bird breeding sites (Hamer *et al.*, 2001). Habitat characteristics such as vegetation type, vegetation closeness, height and inclination are also important factors in nest site selection of marine birds (Fasola & Canova, 1991). All these properties are important factors on preventing kleptoparasitism; protection of chicks and eggs from predators, extreme weather conditions (Burger & Gochfeld, 1988). Different species has various breeding success rates at different habitat types, and thus different nest site preferences. There was not a comprehensive study on habitat and nest site preference relationship of marine birds in the Northeast Mediterranean. In this study we have counted nests on standardized transects, and analyzed distribution of those nests at different habitat types in order to reveal the nest site selection of marine birds in the region. Nest density information obtained from transect surveys have compared the data with a reliable method on colony size determination, flying bird counts (Gregory *et al.*, 2005). A correlation between two data set is revealed. A previous study conducted on a very large common tern colony has also revealed a positive correlation between nest counts and bird counts (Chabot et al, 2015). Results of these studies show that both transect surveys on which nests are counted and flying bird counts are reliable methods to estimate breeding colony size.

Transect surveys revealed notable relationships between vegetation types and nest density, nest density is very high on grass and forb habitat type; however, the statistical test did not attain significance. This situation might be caused by low sample size. Sample size is an important factor effecting power of the statistical tests; small sample size decrease statistical power of the test and leads to higher possibility of type 2 error (Everitt, 2002). Despite that, when we have tested the effect of pooled habitat types (Herbaceous, woody, bare) the same statistical tests attained significance. Which suggests positive effect of herbaceous plant coverage on marine bird nest density. Our results corroborated previous findings on the effect of habitat quality on breeding bird colonies. Studies conducted on Atlantic coasts of South

America have revealed that Imperial cormorants and rock shags are preferring bare rock regions with high inclination (Punta *et al.*, 2003) while Kelp gulls have higher breeding success at areas with high vegetation cover, but there is not a significant difference in hatching success of covered and exposed areas; effect of the coverage is observed in chick survival (Yorio *et al.*, 1995). Positive effect of vegetation as shelter from direct sunlight could be clearly seen in extremely hot regions such as Siniya Island; for example, hatching success of Socotra cormorants in United Arab Emirates increase by the effect of non-native trees planted by human (Muzaffar *et al.*, 2015). Due to hot and dry climate of Mediterranean, building nests close to shade of plants have vital importance for gulls. Another study which has used long term monitoring data obtained from Portugal Coasts between 1979 and 2014 has revealed that Little tern colonies are changing breeding location due to overgrowth of the vegetation (Lopes *et al.*, 2015). There is not such a relationship revealed by our study, but marine birds in the region do not prefer forest or olive stand habitats which have high canopy. Although vegetation cover has an important effect on nest site selection, there are many other factors that could affect breeding success and colony size, such as distance to mainland, area of the island. Family Laridae shows great plasticity in preference of habitat characteristic of nesting site (Borboroglu & Garcia, 2004), so it is possible to observe different nest site preferences even for the same species in different conditions. Distance to mainland is another important factor which effects nest selection of kelp gulls (Borboroglu & Garcia, 2004). In our study the correlation between island distance and nest density was also checked, but the test shows there is no correlation between those two variables. Difference between two studies might be caused by scale of the distance. While distances in Borboroglu & Garcia's study were varied between hundreds of meters to tens of kilometers; the maximum distance in our study site is c. 2250 meters; such small distances could not prevent terrestrial mammal dispersal (Sara & Morand, 2002).

Invasive mammals, especially rats and rodents, are major threat to marine bird populations globally; presence of introduced mammals has negative effects on breeding success and adult survival of marine bird species (Russel & Le Corre, 2009). In this study we have surveyed the effects of invasive mammals on breeding colonies and habitat. Presence of rabbits were detected on four of 14 surveyed islands, goats were seen on one island. We could not conduct a survey for rat

presence on islands. Effect of invasive mammals on vegetation of islands and nest density clearly seen on graphics; however, statistical tests did not attain significance. As previously discussed, this situation could be caused by low sample size. Woody plants and high ratio of area without vegetation is seen on mammal bearing islands, and mean nest density on those islands is 12 fold lower than that of mammal free islands. Direct effects of introduced mammals on marine birds, such as predation, has been widely documented. Presence of introduced predators cause decrease in population size of native bird species; the rate of the decrease and extinction probability depend on level of isolation and response of the species to predation (Blackburn *et al.*, 2004). Marine birds are vulnerable against terrestrial predators; marine bird eggs, chicks and adults are constituting a quarter of diet of invasive rat species (Caut *et al.*, 2008). A study which analyses the situation of 75 marine bird species on 61 island and island chains, has revealed that Hydrobatidae populations are the mostly affected marine birds from invasive rats, while Laridae family were the least affected populations; the study has revealed that size of the bird species had no significant effect, but burrow-nesting and nocturnal behavior might be the reason of the high vulnerability of the some species (Jones *et al.*, 2008).

Predation is not the only effect on marine bird species, herbivore species could also cause decline in marine bird populations by changing environment on which marine birds breed (Strauss, 1991) as also suggested by our survey. Habitat destruction due to invasive mammal presence is a global threat to ecosystems. Level of threat on island ecosystems are much higher than terrestrial ecosystems; due to isolation, lack of predators of invasive species island habitats are more prone to be disturbed by intense invader activities (D'Antonio & Dudley, 1995). Introduced rodents might cause change in habitat structure, loss of breeding grounds, even could change energy and chemical flow dynamics of the island by intense grazing activity (Crooks, 2002).

Another less well known threat to island ecosystems and marine birds is the effect of introduction of prey and predator invaders together; natural prey abundance on island could cause a fast increase in number of invasive predators, high predator population cause rapid decline in prey population which cause a dietary shift in crowded predators, this process is called hyperpredation (Courchamp *et al.*, 2000),

even adults of some marine bird species are easy indigenous preys for invasive predators (Peck *et al.*, 2008). Overall, the pressure on marine bird species has reached to such extend that 83% of the 968 island on which 1362 threatened marine bird species breeding have mammal invaders (Spatz *et al.*, 2013).

Eradication of invasive species by using rodenticides is the most effective method to protect island ecosystems and marine bird populations. There have been 332 successful eradication campaigns globally. While 35 campaigns were failed; all eradication work were done by using rodenticides, except in very small islands (Howald *et al.*, 2007). Positive effects of rodent eradication on marine bird colonies could be observed as quickly as one year after the campaign; extirpated bird species also return to breed on the island in five years after eradication (Croll *et al.*, 2015). Howland, Baker and Jarvis Islands on Equatorial Belt are good example of application of wrong and right rodent eradication methodology; during 1930s cats were brought to the islands in order to control invasive rodent population on the islands. Although cats have successfully extirpated large rat species, they also started to hunt marine bird species and caused extirpation of six marine bird species from the islands and decrease breeding success of larger species by eating chicks (Rauzon *et al.*, 2011). In the end of 1980s feral cats on the islands went extinct naturally or eradicated by human; all of extirpated marine bird species have started to breed on the islands again after 25 years of eradication of cats (Rauzon *et al.*, 2011). The effect of invasive mammals on marine birds is more complex in Western Mediterranean. Although many island on the region host invasive rat species, there is no report on extinction of marine birds due to invasive mammal effect; only significant effect on breeding success is observed on storm petrel species. Intra-island refuges, breeding behavior and life history of marine bird species could be the explanation of the situation, but lack of sufficient data from many sites and bird populations is stressed in the study (Ruffino *et al.*, 2009). More data from a long term monitoring, and studies on rat presence are required to elucidate the situation in Northeast Mediterranean region.

In addition to threats like breeding habitat disturbance caused by invasive mammals, or ones caused by human activities like hunting, construction, and bycatch (Regular *et al.*, 2010); disturbance of breeding colonies by human visits and recreational activities is another threat to breeding success of marine bird

populations, especially on the early days of nesting and hatching (Anderson & Keith, 1980). Recreational activities look like one of the biggest disturbing factor and threat for marine birds in the northeast Mediterranean coasts. Due to easy proximity to islands, anglers, scuba divers, boats are visiting the islands frequently and could spend long time nearby and on islands. During our surveys we have seen anglers, scuba divers on several islands. Also, presence of dense litter on some islands a strong indicator of human presence and activities on the islands; precautions, even bans, should be taken in order to protect marine bird species in the region, especially Audouin's gull. Defense behavior of marine birds generally includes aggressive flight (Kazama & Watanuki, 2010) which cause exposure of eggs and chicks to direct sun light and heat. Exposure to direct sun light has severe, lethal effect even on precocial chicks of gull species (Bartholomew & Dawson, 1954). Strong correlation between number of visitors and decrease in breeding success on marine bird populations on California has been demonstrated (Anderson & Keith, 1980). Not only recreational fishermen or visitors might cause that disturbance; scientific surveys could also affect marine bird populations negatively, 10% of reported disturbances caused by scientists is on marine bird colonies (Götmark, 1992), so all steps of the survey should be designed to spend least time as possible; non invasive methods like census and mapping by Unmanned Aircraft Systems could also be developed (Grenzdörffer, 2013), but in order to implement reliable algorithms a large set of observations on different conditions are required.

Besides habitat properties of islands, properties of marine habitat could also have important effects on breeding colony distribution. Geographical clustering of breeding colony hosting islands into three (I1, I2; I8, I10, I11, I21; I12, I13) and absence of colonies on the most westward islands are notable results. Foraging range of Yellow-legged gulls is estimated to be around 40 km (Neves *et al.*, 2006); when this distance is considered with the distance between colony clusters, it could be speculated that presence of upwelling regions or river inputs may have an effect on this structure. 75 km coastline between Cape Sancak and Kızılliman is a Marine Protected Area on which only artisanal fisheries are allowed (Gücü & Öztürk, 2010). Presence of breeding colonies on this protected area while there are no colonies on non-protected western coasts could be interpreted as positive effect of protection acts.

All these findings and records are important to elucidate distribution and status of marine birds in the region, and form a basis for following monitoring studies. But, further studies which includes western shores of Anatolia, integration of the data to metadata and comparison are required to elucidate reasons of this heterogeneous distribution.

We have conducted a population genetics study on which we have used Control Region of mtDNA as a marker. Eighteen samples from different populations were sent to sequencing and an unexpectedly low variation in control region is detected. Lower evolution rate in gull mtDNA control region, especially on third segment, compared to other taxa has been reported; this situation might be caused by secondary structures formed in the third segment of the region (Crotchet & Desmarais, 2000). Another interesting point is high NCBI BLAST scores with *Larus relictus*, but not with previously uploaded *L.audouinii* sequences. When our sequences and partial Mitochondrial Control Region sequences of 94 other gull species aligned with complete mitochondrial genome of *L.relictus* (*Seq. ID: KC760146.1*) it is clearly seen that PCR product in our study is former part of Mitochondrial Control Region. It matches with 15734th base of *L.relictus*; while sequences of other gulls started at 15964th base. *L.audouinii* samples of the study placed on a branch close to *L.relictus*, but other *Larus* species are located at far branches. Further and more comprehensive studies with more markers would reveal interesting evolutionary relationships and conservation level of the D-Loop region.

Although unexpectedly low variation in the locus of interest has resulted in failure to assess population structure of Audouin's gull population breeding in the study area, and its relation with other breeding colonies; very low variability might be result of some incidents in the past and behavior of the species. Genetic variability of a species decrease when its effective population size drops to extremely low numbers, this phenomenon is named genetic bottleneck (Allendorf & Luikart, 2007). Audouin's gull experienced such a bottleneck, population size of the species was estimated to be 1000 pairs in 1975 (BirdLife International, 2017b); when this low number is considered with properties of mitochondrial inheritance, very low effective population size might cause disappearance of other alleles due to genetic drift and extremely low variability in mitochondrial DNA (Gillespie, 2004). No difference

between distant populations could be explained by migrating behavior of the species. Formation of new colonies (Gutierrez & Guinart, 2008), or preferring to breed in new colonies in good conditions (Oro & Ruxton, 2001) has been reported. In addition to those records in western populations; a ringed subadult was recorded on Göksu Delta (Ganzeveles, 2013), origin of the individual is Aegean Islands population (European Colour-Ring Birding, n.d.). Presence of an individual from that distance in the beginning of breeding season could be interpreted as an evidence for a potential gene flow between eastern and western populations, but more survey and stronger evidences are required.

Another possible explanation of the results is DNA contamination. However, sampling of specimens were conducted by three different groups; DNA isolation was done in two laboratories with different methods; all negative controls in PCR optimization process were give expected result, so probability of contamination is quite low.

Mitochondrial DNA Markers has been used in genetics and phylogeography studies for decades, because they have many advantages and uses such as high number of copies in one cell (Avise *et al.* 1987), high variability in non-coding regions (Simon, 1991), taxa specific molecular clock property in specific regions (Atkinson *et al.*, 2009). Despite gains from these studies; use of mtDNA has long been debated because of some properties of mtDNA, such as maternal heredity, and more importantly strong linkage of mitochondrial genes (Zink & Barrowclough, 2008); due to lack of crossing over event on mtDNA (Klug *et al.*, 2012) no matter how many loci has been sequenced, only one gene tree is obtained. However, gene trees of many loci is required to obtain more reliable results on demography and connectivity studies, which gives nuclear markers advantage against mtDNA markers (Dolman & Moritz, 2006). Another weakness of mitochondrial DNA markers is large confidence intervals in effective population size, gene flow and divergence time (Edwards & Beerli, 2006). Although those constrains, there are several studies on gull species on which mtDNA control region was used and important results have been obtained. Samples taken from six Alaskan, eight Canadian Ross's gull (*Rhodostethia rosea*) museum specimens, and 515 bp of their control region have been analyzed to find phylogenetic relationship of the populations. Six haplotypes

have been defined whose distance is long as 5 base difference have been defined for samples; while two close haplotypes were observed in Canadian samples; six haplotypes have been represented in Alaskan populations which include Canadian haplotypes too. Although its small sample size this study suggests a dispersal and founder effect from Alaskan populations to Canada (Royston & Carr, 2014). Control Region Domain I is used in order to elucidate population structure of Ivory gull (*Pagophila eburnea*) whose breeding colonies are distributed on Arctic Ocean. 264 bp of mtDNA Control Region of 127 museum specimens have been compared; seven haplotype have been defined. Distance between those haplotypes are not more than five bases; and they are all shared by different populations (Royston & Carr, 2016). This result has suggested there is a high level of gene flow between populations, and all those populations could be considered as a large single population (Royston & Carr, 2016). Liebers and Helbig have used HVR I in phylogeny study of Lesser Black Backed Gull group (*Larus fuscus*). In this study they have detected 44 haplotypes in 272 samples from five taxa in the group; 32 of these haplotypes have been found only in one population, and 26 of them have been possessed by single individual (Liebers & Helbig, 2002). Although number of haplotypes are high; those haplotypes are shared highly by all five taxa; results of the study suggests low inter and intra species diversity (Liebers & Helbig, 2002). The same group also studied HVR I of Yellow-legged Gull Group (*Larus cachinnans*) which consists of six species includes *Larus michahellis* (Liebers *et al.*, 2001) and their relationship with *Larus fuscus* group. 430 bp sequence of 580 samples have been analysed; 90 haplotypes have been detected, 26 of them have been shared by at least two populations (Liebers *et al.*, 2001). This study have revealed that population structure between Yellow-legged Gull Group and Lesser Black Backed Gull Group is higher than previous allozyme and AFLP studies have been suggested (Liebers *et al.*, 2001).

Aim of the study and sample size has great importance on selecting marker which will be used in the study; using one mtDNA and several nuclear markers is the ideal setup. There is an unsuccessful attempt to elucidate population structure of Audouin's gull on which several microsatellite markers were tried, but only three of them have worked, and number of alleles were too low to give reliable results (Genovart *et al.*, 2003). At least 30 microsatellite markers have been defined for Larus species (Sonsthagen *et al.*, 2012); American Herring gull (Crochet *et al.*,

2003), Herring gull (Gregory & Quinn, 2006), Red-billed gull (Given *et al.*, 2002), Ivory gull (Yannic *et al.*, 2011). Some of those markers are reported to be giving high variability which could be used in genetics studies of other species (Given *et al.*, 2002). Due to time restriction and scope of the study, trial of microsatellite markers developed for other gull species, or development of new microsatellite markers are not attempted, and usage of Highly Variable Region 1 section of the control region is decided. It is necessary to use nuclear markers in further studies whose focus is population structure and connectivity of gull populations. Conducting genetic studies combined with ringing effort would be a great leap to elucidate population dynamics of the species.

5-CONCLUSION

Three marine bird species are breeding between the beginning of March to the end of June, on the islands at southeast Mediterranean coasts of Anatolia. Size of those colonies are small compared to global populations of the species. Habitat type of islands have important effect on nest density and colony sizes. Presence of invasive mammals are observed on several islands; mammal presence has notable effect on vegetation type and habitat characteristics of islands. It is also observed that, invasive mammal presence indirectly cause a notable decrease in nest density. High recreational use of islands by humans were also observed, that situation is a major threat to breeding marine bird populations in the region. High mortality of Audouin's gull chicks was remarkable in the breeding season of 2016. When high anthropogenic pressure, presence of invasive mammals are considered together with low population size status and health of marine bird populations breeding in northeast Mediterranean is not well. Populations and habitat are under high threat; presence of the species in the region will be at risk, if some precautions would not be taken.

Extremely low variability in Control Region of Audouin's gull is revealed in the study. Phylogenetic analysis revealed close relationship of *L.audouinii* with *L.relictus,* but two species are depicted far from other *Larus* species. Definition of

COI markers of the *L.audouinii* in the region should be done to understand phylogenetic relationship with other gull species. *E*xtra low variability could be indicator of a genetic bottleneck incident in the past of the species and high gene flow between geographically distant populations.

6-PERSPECTIVE

In order to continue monitoring of island habitats, and human pressure on coastal ecosystem; surveys of vegetation types, coverage, plant height on islands should be done in regular periods by using same methods applied in this study. Description of plants in species level may have importance.

Bird counts, nest counts should be done annually to understand population trends of marine birds who breed in the region. Egg counts and dimension measurements should also be done to obtain important information on breeding success of species.

Chick counts, weighing, measurement of beak, wing and tarsus should be done regularly in order to understand growth rate of the chicks and foraging success of parents.

Ringing of chicks should be done regularly with genetic sampling in order to understand dispersion of the populations, breeding success of parents and adult mortality in long term.

A more comprehensive mammal survey should be done on the islands. According to results of those surveys management plans should be developed for eradication of invasive mammals. Experiments on effect of invasive mammals on island habitats and breeding colonies may also be designed by using some islands as control groups.

DNA barcoding of *Larus audouinii* should be done to elucidate phylogenetic relationship with other marine bird species by amplifying and sequencing COI region of the species.

Microsatellite markers developed for other gull species should be tried on genetic studies of the gulls of the region. Highly polymorphic microsatellites will give important information on phylogeny and recent changes of the population structure.

Whole genome analysis of some individuals would create a high advantage in population genetics studies of the species, more specialized genetic markers could be developed by using whole genome information, and more comprehensive results could be obtained by using SNP data.

Standardization of data, and collaboration with other governmental institutions, research groups, conservation societies have vital importance to create reliable bio-indicators for marine ecosystem, and of course protect those species from extinction.

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TEZ FOTOKOPİ İZİN FORMU

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YAZARIN

Soyadı : Yapan
Adı : Batuhan Çağrı
Bölümü : Deniz Bilim (Oşinografi)

TEZİN ADI (İngilizce) : BREEDING MARINE BIRDS IN THE SOUTHEAST MEDITERRANEAN COASTS OF ANATOLIA: HABITAT-POPULATION SIZE RELATIONSHIP, AND GENETIC STRUCTURE OF THREATENED AUDOUIN'S GULL POPULATION

TEZİN TÜRÜ : Yüksek Lisans ■ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ■

Yazarın imzası ..... Tarih .....