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OVERVIEW OF THE GUT MICROFLORA IN WILD-CAUGHT FISH AT THE LEBANESE SHORE

by
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AN ABSTRACT OF THE THESIS OF

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Microflora refers to the collection of live microscopic organisms that flourish inside the organs of living creatures including fishes. Bacteria living on the inner intestinal walls play an important role in digesting food, absorbing nutrients and defending the host from outer pathogens. All living organisms including fish interact with and are affected by bacteria. However, the gut flora of wild fish remains poorly characterized. The aim of this work is to provide an overview of the bacteria colonizing the gut of wild-caught fish. After isolation of cultivable bacteria, 16s ribosomal DNA sequencing was performed for identification purposes. R program was then used to compare sequences corresponding to bacteria from 15 different fish species divided into three categories based on their habitat, diet and origin. The potential pathogenicity of some bacteria was also investigated using the model organisms *Danio rerio* and *Drosophila melanogaster*. *Serratia* and *Aeromonas salmonicida* were lethal to *Drosophila* while all *Danio rerio* fish didn't show any distress symptoms when exposed to these bacteria. This study paves the way to a more complete project including the identification of the uncultivable bacteria that reside in the gut, the examination of several specimens per fish species and the extension of the analysis to a larger number of fish species.

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ABBREVIATIONS

%	Percent
/	Per
≈	Almost equal
PH	Power of Hydrogen
G	Grams
CFU	Colony-forming unit
°C	Degrees Celsius
PCR	Polymerase Chain Reaction
µl	Microliter
$MgCl_2$	Magnesium Chloride
mM	Millimolar
dNTPs	Deoxynucleotide Tri Phosphate
rRNA	Ribosomal ribonucleic acid
16s rRNA F	Forward primer
16s rRNA R	Reverse primer
DNA	Deoxyribonucleic acid
min	Minutes
ml	Milliliter
TBE	Tris/Borate/EDTA buffer
mg	Milligram
UV	Ultra-Violet
V	Volts
g	G-Force
M	Molar
ng	Nanogram
NaCl	Sodium Chloride
EDTA	Ethylenediaminetetraacetic acid
SDS	Sodium dodecyl sulfate
STE	Nacl/Tris/EDTA buffer
p-GEM-T	Promega vector
$CaCl_2$	Calcium chloride
DH5α	Competent *E. coli* cells
LB	Luria Bertani broth
AMP	Ampicillin
Solution I	Tris/EDTA/Glucose
Solution II	NaOH/SDS
Solution III	KOH/Acetic acid/ H_2O
EcoRI	Endonuclease enzyme
X-Gal	5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside
IPTG	Isopropyl β-D-galactoside
L	Liter
OD	Optical Density
Hrs	Hours
nl	Nanoliter
PBS	Phosphate buffered saline

CHAPTER I

INTRODUCTION

A. The Mediterranean and modes of fish introduction:

It is widely accepted that the Mediterranean Sea is populated by organisms from the Atlantic Ocean when connection was reestablished after the Messinian period (McKenzie, 1987; Por and Dimentman, 1989). Nowadays, the Mediterranean is a semi-enclosed sea connected to surrounding water bodies by the Strait of Gibraltar, the Dardanelles and the Suez Canal.

Hundreds of non-indigenous marine species thrive in the Mediterranean Sea. They were introduced by several means such as ballast waters, aquaculture or as fouling organisms (Coll et al., 2010). However, the most important source of introduction is undoubtedly by crossing the Suez Canal. The connection between the Red Sea and the Mediterranean allowed a massive flow of organisms from the Indo-Pacific realm. This process was termed Lessepsian Migration (Por, 1978; 2010). Today, the number of bony fish species of Indo-Pacific origin has exceeded 89 species and this number is expected to increase further in the future (CIESM, 2016).

B. Microflora and modes of ingestion:

Microflora refers to the living microscopic organisms that flourish inside and on the surface of living creatures, including fishes. These organisms are usually found on the skin, tissues and inside guts (Cahill, 1990; Austin, 2006). Bacteria living on the inner intestinal walls play an important role in digestion, absorption and in defense against pathogens (Cahill, 1990; Austin, 2006).

The composition of microbial communities within fish guts differs significantly from those living in the surrounding environment in both diversity and specificity (Austin and Austin, 1987; Cahill, 1990; Ringø et al., 1995). Some of these bacteria permanently occur within the microflora while others appear to be transient (Cahill, 1990). These bacteria reach the inside of the organisms through different means. While some are ingested during the larval stage and may establish in the guts of juvenile fishes others may result from the intimate contact of egg chorions with bacteria in the aqueous environment (Hansen and Olafsen, 1999). Adapting to gut environmental conditions like nutrient availability, pH and digestive enzymes remain the key factor for those bacterial communities to proliferate and thus persist within the intestines (Hansen and Olafsen, 1999). The composition of the gut microflora changes in response to a variety of factors affecting the host, such as feeding strategies, developmental stages, digestive physiology and changing environmental conditions (Yoshimizu and Kimura, 1976; MacFarlane et al., 1986; Cahill, 1990; Vemer-Jeffreys et al., 2003; Romero and Navarrete, 2006; Uchii et al., 2006).

C. Interactions between microbial communities and their hosts:

Microbial communities are known to help in the digestion. They interact with their hosts in several ways, affecting nutrition, growth, reproduction and vulnerability of the host to diseases. In addition, they have an impact on the overall population dynamics (MacFarlane et al., 1986). As such, *Bacteroides* and *Clostridium* spp. were shown to enhance nutrition by providing essential fatty acids and vitamins (Ringø et al., 1995). *Lactobacillus* spp. may be more or less important components of microflora communities promoting fish health and preventing the establishment and growth of potential pathogens (Strøm, 1988; Izvekova et al., 2007).

D. Composition of microflora:

Different studies showed that the composition of gut microflora varies among different fish species. However, differences and inconsistencies among methods do not allow direct comparisons between species. Studies used culture-based techniques to identify bacteria providing valuable insights into the composition of microbial communities (Newman et al., 1972; MacFarlane et al., 1986; Spanggaard et al., 2000; Aschfalk and Muller, 2002; Verner-Jeffreys et al., 2003; Al-Harbi and Naim Uddin, 2004; Martin-Antonio et al., 2007; Skrodenytė-Arbaĉiauskienė, 2007). However, these studies were mostly focused on fish grown in farms and they provided biased assessments of the microbial community composition since typically less than one percent of microflora cells produce colonies when cultured on solid media (Ferguson et al., 1984; Head et al., 1998). Gamma-Proteobacteria such as *Aeromonas* spp., *Escherichia coli*, *Photobacterium* spp., *Pseudomonas* spp. and *Vibrio* spp., dominated the gut microbiome of most fishes (Newman et al., 1972; MacFarlane et al., 1986; Ringø, 1993b; Ringø and Strøm, 1994; Spanggaard et al., 2000; Verner-Jeffreys et al., 2003; Al-Harbi and Naim Uddin, 2004; Bates et al., 2006; Romero and Navarrete, 2006; Skrodenyte-Arbaciauskiene et al., 2006; Martin-Antonio et al., 2007; Skrodenytė-Arbaĉiauskienė, 2007; Ransom, 2008; Ward et al., 2009). It was estimated that some bacterial populations reach 10^8 aerobic bacteria and 10^5 anaerobic bacteria per gram of gut content with different abundances within the gut of the same fish (Austin, 2006).

E. Environmental stressors and alteration of the composition of gut microflora:

The composition of gut microflora is altered with the changing environmental conditions and stressors where the composition of the transient microflora is reported to be affected by environmental factors, by bacteria presence in the water column and with a changing diet (Hansen and Olafsen, 1999; Nayak, 2010). Since stressors such as temperature, low oxygen concentration and pollutants may weaken the immune system of the host, the presence of pathogens in the surrounding environment may affect the fish health negatively as these opportunistic cells may colonize the host's gut (Hansen and Olafsen, 1999).

Variations in salinity and temperature also play a major role in the composition microflora communities in fishes. Yoshimizu and Kimura (1976) and MacFarlane et al. (1986) documented shifts in the composition of fish gut microflora coinciding with salinity variations encountered in estuarine environments. Other studies showed that many freshwater fishes contain *Aeromonas* sp. within their guts while *Vibrio* sp. was documented in estuarine and marine species (Cahill, 1990; Ringø et al., 1995; Ringø and Birkbeck, 1999). This suggests that any change in the salinity of water due to global warming or raining patterns may lead to an alteration in the microflora community in fish's gut. The potentially pathogenic *Vibrio vulnificus* was detected in the sheepshead (*Archosargus probactocephalus*, Sparidae) sampled from the Gulf of Mexico (DePaola et al., 1994; 1997). The presence and abundance of this bacterium is closely linked to increased water temperature, with highest densities occurring when water temperatures range between 20 and 30^{o}C (Kelly, 1982; DePaola et al., 2003; Tantillo et al., 2004). Although this bacterium is naturally present within the sheepshead gut, it was recorded that its increased abundance is correlated with warmer water temperatures where densities were 2-3 orders of magnitudes lower in March and December (colder period) compared to those in May and September (warmer period) (DePaola et al., 1997).

F. Pathogens and seafood illness:

Human pathogens can be found in the fish gut microflora and play a major role in seafood-associated bacterial illness and mortality. *Vibrio parahaemolyticus* and *V. vulnificus* are leading causes of human and marine mammals casualties although several members of this genus are nonpathogenic and are found to be the dominant bacteria in and on marine fishes (Iwamoto et al., 2010). They have been commonly reported as members of the gut microflora in both farmed and wild fishes (MacFarlane et al., 1986; Cahill, 1990; Sakata, 1990; Blanch et al., 1997; Martin-Antonio et al., 2007; Ward et al., 2009; Iwamoto et al., 2010). Most infections involving these two bacteria are through consumption of raw or undercooked seafood, while others results from wound infections leading to gastroenteritis, septicemia and *V. vulnificus* septicemia (Constantin de Magny et al., 2009). Infections with *V. parahaemolyticus* are the leading cause of bacterial illnesses from seafood consumption in the United States with 22.5% hospitalization and 0.9% mortality rates (Iwamoto et al., 2010; Scallan et al., 2011). However, *V. vulnificus* infections are rare but they are the leading cause of seafood-related deaths with a 91.3% hospitalization and 34.8% mortality among all foodborne pathogens (Iwamoto et al., 2010; Scallan et al., 2011).

Photobacterium damselae, which is a virulent strain, can also impact fish and humans causing septicemia and internal hemorrhage in fish and septicemia and wound infections in humans (Shin et al., 1996; Fouz et al., 2000). *Photobacterium damselae* subsp. *piscida,* which is a subspecies of *P. damselae,* is not a human pathogen but it is a serious fish pathogen leading to high levels of mortality (Thyssen et al., 1998; Fouz et al., 2000). *Streptococcus inae*, *Aeromonas hydrophilia*, *Edwardsiella tarda*, *E. rhusopathiae*, *Mycobacterium marimum* and other *Vibrio* spp. are additional pathogens leading to human diseases (Zlotkin et al., 1998; Lehane and Rawlin, 2000; Colorni et al., 2002).

Transmission of pathogens may also occur via infections and open wounds if gut microflora can persist in water. Cahill (1990) showed that *Aeromonas* spp.'s population increased in seawater aquarium when fishes stayed for longer times (181 days). But, since *Aeromonas* spp. were not isolated from seawater, it was suggested that this population is a result of accumulation of fish feces in the water of the aquarium (Cahill, 1990). Water quality in areas with dense fish populations, in shallow waters, in areas of decreased water flushing and in areas with increased residency may be affected by persisting gut microflora. Also, fish inhabiting water polluted by human sewage may become a carrier or vector of human diseases representing a great public health threat (Janssen and Meyers, 1968).

Pathogenic bacteria may be also transferred through fish to new hosts like humans and other marine animals. This risk of transmission depends on the interaction between the organism, the physiology of the infected person and other environmental factors (Strom and Paranjpye, 2000; Oliver, 2006). Consumption of raw and undercooked shellfish and fish containing pathogens increases the risk of infection where *V. vulnificus* can move directly into edible portions of the fish from intestines in addition to *E. coli* and *Salmonella* spp. which can move from stomach to blood and fish muscles. Other infections by pathogens can take place during filleting and direct contact and handling of some species (Buras et al., 1985; DePaola et al., 1994).

Fish may be a key link in pathogen cycling between fishes, the water column, sediments and other marine organisms. This theory refers to the point that most pathogens require nutrient rich environments like the gut for growth and survival. These pathogens are then expelled with fecal matter and represent a seed population that can colonize the surrounding environment. Therefore, fishes may play an important role in the epidemiology of illnesses and deaths arising from oyster and shellfish consumption since they harbor potential pathogenic bacteria within their intestines and affect fishes, oceans and human health (Ruby and Nealson, 1978; Givens, 2012).

G. Infections of ectoparasites and nestedness:

Several studies analyzing infections of fish with ectoparasites found nested patterns of parasite occurrence (Gonzalez and Poulin, 2005; Gonzalez and Oliva, 2009; Rohde et al., 1998; Worthen and Rohde, 1996; Poulin and Guègan, 2000). Werner et al. (2009) defined nested patterns as "those in which the species composition of small assemblages is a nested subset of larger assemblages". Different colonization probabilities and dominance of infection of ectoparasites are the main reasons of a nested distribution (Worthen and Rohde, 1996). Any changes in patterns may be due to the interactions with different host fish species, intermediate hosts, host densities and environmental conditions (Gonzalez and Poulin, 2005; Gonzalez and Oliva, 2009).

H. Aims and significance of the project:

The bacterial presence in the guts of wild fishes has rarely been investigated and remains poorly characterized. Furthermore, it is also not known whether introduced fish species acquire a flora similar to that of indigenous species, when sharing a similar habitat and diet, or whether they retain a different gut flora, similar to that of the original habitat. The aim of this work was to provide an overview of the bacteria colonizing the gut of wild-caught native and introduced fishes from off the coast of Beirut (Lebanon) and to compare them according to their habitat, diet and origin. We also attempted to determine whether bacterial species distribution over host fish displayed nestedness and investigated the potential pathogenicity of some bacteria using the model organisms *Danio rerio* (Fish) and *Drosphila melanogaster* (Fruit fly).

CHAPTER II

Materials and Methods:

A. Sampling Design

Gut samples were collected from fish species that were caught in coastal waters around Beirut. 15 different species of fish belonging to different families were collected from Ozaii Port. All fishes were kept on ice when transported to the lab and dissected directly.

B. Polymerase Chain Reaction PCR:

Each PCR mix consisting of 28µl distilled water, 4µl 10X buffer, 3.5µl $Mgcl_2$ (25mM), 0.75µl dNTPs (2mM), 0.75µl 16sF, 0.75µl 16sR and 0.25µl Taq polymerase was added to 2µl DNA template. The PCR program was as follows: Step 1: 95°C for 5 min, Step 2: 95°C for 30 seconds, Step 3: 53°C for 30 seconds, Step 4: 72°C for 2 min, Step 5: repeat steps 2-4 30 times, Step 6: 72°C for 5 min and Step 7: 4°C forever.

C. Gel Electrophoresis:

0.5g of agarose were dissolved in 50ml 1X TBE to obtain a 1% agarose suspension. This mix was heated until no solid particles were found. Then 2µl of Ethidium Bromide (4mg/ml) were added and the mix was poured in a comb holding tray. After the gel solidified, combs were gently removed. 10µl of PCR product were mixed with 2µl 5X loading buffer and then loaded into the wells. The ladder was loaded in the first well of each row. After checking the electrodes and their proper positions the gel ran at 90V for 40 min. The results were checked using UV light.

D. DNA Purification:

PCR product was diluted in water to reach 100µl volume, then samples were mixed with 1 volume of Tris-Saturated Phenol and 1 volume of chloroform. This mix was centrifuged at 15000g for 5 min at room temperature. 90µl of the upper aqueous phase was then transferred to a new tube where an equal volume of chloroform was added and vortexed. The new mix was centrifuged at 15000g for 5 min at room temperature. The upper aqueous phase was transferred to a new tube where 1/10 the volume of 3M sodium acetate solution and 2.5 volumes of ethanol were added to precipitate the DNA. The mix was incubated for 30 min at -80°C then centrifuged for 15 min at 20000g. The supernatant was discarded and the pellet was rinsed with 70% cold ethanol then centrifuged again for 5 min at 20000g. The pellet was left to air dry after discarding the supernatant and resuspended in 12µl of nuclease free water.

E. Preparation of DNA for Sequencing:

After measuring DNA concentration using a Nanodrop machine, it was diluted to 80ng/µl. Then, 8.5µl of DNA was mixed with 1.5µl of 16sF or 16sR primers and 6µl of distilled water.

F. Identification of Species and BLAST (www.ncbi.nlm.nih.gov):

We used the NCBI nucleotide blast facility to compare the 16s sequences we obtained to database sequences.

G. STE DNA extraction:

Intestines were shredded using blades and STE was added proportional to the intestines' sizes (0.5g: 1ml). Tubes were incubated at 95°C for 10 min then centrifuged at 20000g for 10 min. Supernatant was transferred to a fresh tube and 100µl of sodium acetate were added. After a gentle mix, the tubes were incubated on ice for 20 min. Then 630µl of isopropanol were added and tubes were manually mixed by inverting several times. This mix was centrifuged at 20000g at 4°C for 15 min. Supernatant was discarded and the pellet was rinsed with 70% ethanol then centrifuged for 2 min at 20000g. After discarding the supernatant, the pellet was partially air dried (5 min) and resuspended in 100µl distilled water. To make sure all DNA was dissolved, the eppendorf was incubated at 50°C for 30 seconds and vortexed. The dissolved DNA was stored at -20°C or directly used for PCR.

H. Livak DNA Extraction:

Gut samples were homogenized with a sterile pestle in 500µl of pre-heated Livak grind buffer (80mM NaCl, 0.16M sucrose, 130mM Tris Base, 50.8mM EDTA ph= 8.0 and 5mM SDS) in 1.5ml microcentrifuge tubes. The mix was incubated at 65°C for 30 min. Then, 70µl of potassium acetate were added to obtain a 1.0M solution. This solution was mixed gently and incubated on ice for 30 min. Eppendorfs were centrifuged at 4°C at 20000g for 20 min and the resulting supernatant was added to 1000µl of 100% ice cold ethanol and mixed. The tubes were centrifuged at 4°C at 20000g for 15 min to pellet the DNA. Then, the pellet was rinsed with 500µl of cold 70% ethanol. After discarding the supernatant, the pellet was kept to air dry for 5 min, then resuspended in 50µl of distilled water and incubated at 65°C for 10 min.

I. Bacterial Genomic DNA Preparation:

1.5ml of each bacterial culture were transferred to eppendorfs then centrifuged at 6000g for 5 min at 4°C. Supernatant was discarded and the pellet was resuspended in 300µl STE buffer then incubated at 95°C for 15 min. This mix was centrifuged at 12000g for 10 min at 4°C. Then, 200µl of the supernatant were transferred to a clean eppendorf. Tubes were placed on ice and 20µl of 3M sodium acetate were added and mixed gently. Eppendorfs were centrifuged at 20000g for 15 min at 4°C after the addition of 2V of 100% cold ethanol. Supernatant was discarded and the pellet was then washed with 500µl of 70% cold ethanol and centrifuged at 20000g for 5 min at 4°C. Supernatant was then discarded and any residual liquid was removed without dislodging the pellet. This pellet was then left to air dry at room temperature for 5-10 min. Then 50-100µl of distilled water were added and the pellet was resuspended by flicking and heating at 60°C for 5 min before being stored at -20°C.

J. DNA Ligation and Transformation:

3 different reactions were prepared according to the manufacturer protocol (Promega). The standard reaction was made up of 5µl of 2x Rapid Ligation Buffer, 1µl of pGEM-T Easy Vector (50ng), 3µl of PCR Product and 1µl of T4 DNA Ligase (3 units/µl). The background control was made up of the same mix but the PCR product was replaced by 3µl of distilled water. The positive control was made up of 5µl of 2x Rapid Ligation Buffer, 1µl of pGEM-T Easy Vector(50ng), 2µl of Control Insert DNA, 1µl of T4 DNA Ligase (3 units/µl) and 1µl of distilled water. Reactions were kept at room temperature for 2 hours then they were mixed and heated at 65°C for 5 min. 50µl of $CaCl_2$ Competent cells (*E. coli* DH5α) were added to clean pre-chilled eppendorfs

containing 2µl of ligation mix. These eppendorfs were left on ice for 30 min then heat shocked for 2 min at 42°C and returned back on ice. 350µl of LB were added to each eppendorf and 100µl of the mix were plated on LB agar + AMP plates and kept at 37°C overnight. Using a tip, single colonies were inoculated in a 13ml falcon tube containing 3ml of LB+AMP mix and grew overnight at 37°C in a shaker.

K. Plasmidic DNA Mini Preps:

Eppendorfs containing 1.5ml of bacterial culture were centrifuged at 6000g for 5 min at 4°C. After discarding supernatant, 200µl of Solution I were added to resuspend pellet. Then 200µl of Solution II were added and mixed by inverting the eppendorf 2-3 times and left for 5 min at room temperature. 200µl of Solution III were added and mixed by inversion. Tubes were centrifuged at 17000g at 4°C and 500µl of supernatant were transferred into new eppendorfs. Then 350µl of Isopropanol were added and mixed and eppendorfs were centrifuged at 20000g for 15 min. The supernatant was discarded and the pellet was washed with 200µl of 70% ethanol and spun for 5 min at 20000g. Supernatant was discarded and pellet was left to air dry then resuspended in 50µl distilled water. After resuspension, DNA concentration was measured using NanoDrop device.

L. Digestion and Gel Electrophoresis:

A mix containing 5µl of purified DNA, 0.5µl of EcoRI enzyme, 2µl of Buffer and 12.5µl of distilled water was kept at 37°C for 2 hours. Then, this mix was run on a gel to check DNA bands.

M. Plate culturing:

3 small slices from different places of the intestine were cut and ground in 200µl of LB and diluted to reach a volume of 1ml. Plate 50 and 100µl of each mix on different LB plates and keep to solidify at room temperature until colonies were observed.

N. Streaking of Individual Colonies:

Bacterial colonies were checked for their colors and patterns and individual colonies were isolated in proximity to a bunsen burner using a loop. Dishes were kept overnight at room temperature for colonies to grow.

O. Liquid Culture:

In presence of a flame, single colonies were taken using a tip to inoculate a 13ml falcon tube containing 3ml of liquid LB. They were left to grow overnight in a shaker at 25°C.

P. Preparation of Solid Media Plates:

1. Preparation of LB Agar + AMP plates:

200ml of LB Agar were autoclaved then kept at 50°C for 1 hour. 200µl of Ampicillin (100mg/mL) were added and plates were poured next to a flame. As the plates solidified, they were turned upside down and kept at room temperature overnight. Then they were stored at 4°C.

2. Preparation of LB Agar + AMP + X-Gal + IPTG plates:

500ml of LB Agar was autoclaved then kept at 50°C for 1 hour. 500µl of Ampicillin (100mg/ mL), 500µl of 3% X-Gal and 50µl of IPTG (100mM) were added and plates were poured next to a flame. The plates then were covered with aluminum foil.

3. Preparation of LB plates (Luria Bertani Broth):

12.5g of LB and 500ml of distilled water were mixed in a 1000ml flask and autoclaved at 121°C for 20 min. After cooling down at 55°C, LB was poured in plates.

Q. Bacterial Exposure Experiment:

6 containers were prepared by adding 2 liters of tap water, 1 liter of aquarium water and bubblers. 50µl of bacterial mix (OD ≈ 50) were added to 6 small cups containing 100ml of water each and 3 zebra fish were added and left for 45 min. The fish were transferred to 2 liters containers. Different time points were set to determine any change in the behavior of fish (3hrs, 6hrs, 9hrs, 12hrs, 24hrs, 36hrs, 48hrs, 60hrs and 72hrs).

R. *Drosophila* Injection:

32nl bacterial suspension (OD= 0.15) were injected into the thorax of wild type *Drosophila melanogaster* using a Nanoject II apparatus. Each experiment was performed using 15 flies in fresh vials and the survival was monitored by counting the flies at regular intervals after injection.

S. OD Measurement:

Bacterial cultures were centrifuged for 5 min at 6000g. Supernatant was removed and the pellet was vortexed in the residual volume of LB and transferred to an eppendorf. 10µl of bacterial culture was added to 990µl of water, PBS or 0.9% saline solution in a clean cuvette. After mixing, OD was measured using a spectrophotometer.

T. Data Analysis:

The statistical programming language R (R Core Team 2015) was used for data analysis.

1. Defining Operational Taxonomic Units

An alignment of 16s nucleotide sequences was used to define bacterial operational taxonomic units (OTUs). The proportion of nucleotides that differ between 16s sequences was calculated for all sequence pairs and a graph was constructed treating 16s sequences as vertices and connecting all vertices that differ by less than 5% of the nucleotide positions. The maximal cliques (i.e. fully connected subgraphs) were determined for this graph using the function *clique* in the R package *optpart*. Vertices that belonged to multiple cliques were arbitrarily assigned to one of the cliques they belong to. The cliques were considered OTUs. This procedure ensured that all members of the same OTU differ by not more than 5% of their nucleotides. However, some members of different OTUs could differ by 5% or less.

2. Analysis of the Community Matrix

A binary community matrix was created to indicate which bacterial OTU occurred within which fish species. This community matrix had one row per bacterial OTU and one column per fish species and contained a one if the respective OTU was present in the fish species and a zero otherwise. The nestedness of this community matrix was analyzed using the function *nestedtemp* in the *vegan* package. Furthermore, the community matrix was used to calculate pairwise Euclidian distances between

OTUs and between fish species. For each set of pairwise distances (one for the OTUs and one for the fish species) multidimensional scaling was applied to represent the species as points in two-dimensional space (function *cmdscale* in *stats* package). These points were plotted to determine by visual inspection whether either fish species or bacterial OTUs form distinct clusters.

CHAPTER III

Results:

A. Fish collection and bacteria cultivation:

Fifteen different fish species were collected from Beirut seashore (Figure 1). Fishes were identified and categorized according to their diet, origin and swimming mode (Bariche, 2012). Dissected guts were ground with their contents in LB, spread on agar plates and incubated at room temperature to allow the growth of bacterial cells. Different colonies were removed and streaked on different plates after noting their appearance, relative abundance and color. Identification of fishes and shapes of bacterial colonies are summarized in Table 1 and Table 2.

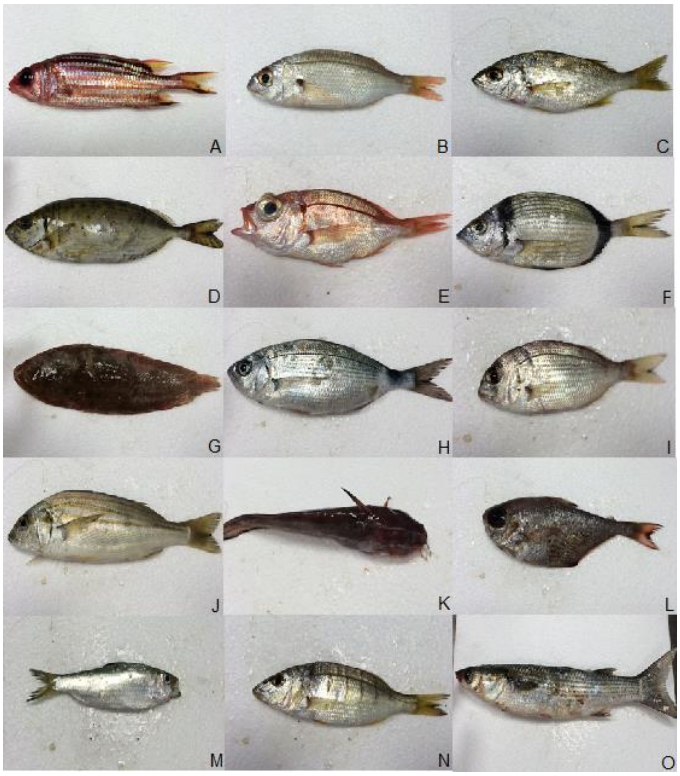

Figure 1. 15 species of wild-caught fishes. A: *Sargocentron rubrum,* B: *Pagellus acarne*, C: *Pomadasys incisus*, D: *Siganus rivulatus*, E: *Dentex macrophthalmus*, F: *Diplodus vulgaris*, G: *Dicologlossa cuneate*, H: *Oblada melanura*, I: *Pagellus erythrenus*, J: *Pomadasys stridens*, K: *Plotosus lineatus*, L: *Pempheris mangula*, M: *Sardinella maderensis*, N: *Lithognathus mormyrus*, O: *Liza aurata*

Species	Common Name	Fish ID	Carnivore vs. Herbivore	Pelagic vs. Benthic	Lessepsian vs. Native	Description of colonies on petri dish	Number of different colonies picked
Sargocentrom rubrum	soldier fish	1	C	P	L	carpet + individual, colonies on top	grey carpet, white, pink, black only 2
Pagellus acarne	sea bream	2	C	P	N	a lot but not a carpet, almost	bright orange, grey, yellow, white, black white, pink
Pomadasys incisus	bastard grunt	3	C	B	N	a lot but not a carpet, almost	grey carpet, bright orange(a lot), black, white, yellow, pink, yeast like (white/cream-pink)
Siganus rivulatus	rabbit fish	4	H	P	L	individual colonies	very small yellow, big cream-pink, white, pearl white, yeast white, transparent
Dentex macrophthalmus	large eye dentex	5	C	B	N	carpet, grey + colonies on top	white/grey, cream-pink, bright pink, pearl white, bright orange
Diplodus vulgaris	two banded sea bream	6	C	B	N	carpet, grey + colonies on top	white, carpet, white/cream-pink, bright orange, 1-2 small yellow, black(center of the colony)
Dicologlossa cuneate	sole	7	C	B	N	carpet, grey + colonies on top	grey carpet, white, white/cream-pink, bright and small orange
Oblada melanura	saddled sea bream	8	C	P	N	carpet, grey + colonies on top	pink, white/pink, carpet, white irregular shape (yeast like)
Pagellus erythrinus	pandora	9	C	B	N	no carpet, individual colonies	yellow, cream-pink/white irregular big, white round
Pomadasys stridens	striped piggy	10	C	P	L	carpet +individual	carpet, white/cream-pink
Plotosus lineatus	cat fish	11	C	B	L	carpet +individual	carpet, white/pink, 1-2 bright orange
Pempheris mangula	sweeper	12	C	P	L	almost no carpet, individual	bright orange, yellow, white, white/cream-pink
Sardinella maderensis	sardine	13	C	P	N	carpet on big plate, individual	pink, carpet, white
Lithognathus mormyrus	sand steenbras	14	C	P	N	carpet on big plate, individual	pink, 2-3 yellow, white, white/cream-pink
Liza aurata	mullet	15	C	P	N	no carpet, individual colonies	small pink, yellow, irregular(yeast like) cream-pink

Table 1. Fish species

B. Identification of cultivable bacteria:

In total, seventy different colonies were isolated on LB agar plates. Based on the colony morphology, we suspected two isolates to be yeast colonies and 16s ribosomal RNA gene amplification was not successful with their DNA. Seven bacterial colonies were not able to grow in liquid culture media and were subsequently discarded. The remaining sixty-one bacterial colonies were lysed to prepare genomic DNA from each. Then, 16s gene was amplified and sequenced for identification purposes. The results were as follows:

- Three bacterial species were cultured from *Sargocentrom rubrum* (*Staphylococcus hominus, Shewanella baltica* and *Psychrobacter faecalis*).
- Four bacterial species were cultured from *Pagellus acarne* (*Psychrobacter species, Psychrobacter species, Shewanella species* and *Aeromonas salmonicida*).
- Seven bacterial species were cultured from *Pomadasys incisus* (*Psychrobacter faecalis, Planococcus species, Psychrobacter faecalis, Shewanella putrefaciens, Planococcus species, Psychrobacter species* and *Arthrobacter species*).
- Three bacterial species were cultured from *Siganus rivulatus* (*Shewanella species, Kocuria rhizophila* and *Psychrobacter species*).
- Four bacterial species were cultured from *Dentex macrophthalmus* (*Psychrobacter maritimus, Planococcus species, Shewanella baltica* and *Psychrobacter species*).

- Five bacterial species were cultured from *Diplodus vulgaris* (*Psychrobacter cibarius, Psychrobacter faecalis, Psychrobacter species, Arthrobacter species* and *Psychrobacter species*).
- Three bacterial species were cultured from *Dicologlossa cuneate* (*Shewanella species, Shewanella baltica* and *Psychrobacter species*).
- Four bacterial species were cultured from *Oblada melanura* (*Psychrobacter maritimus, Shewanella baltica*, *Psychrobacter faecalis* and *Psychrobacter putrefaciens*).
- Three bacterial species were cultured from *Pagellus erythrinus* (*Shewanella putrefacien*, *Vibrio metschnikovii* and *Arthrobacter species*).
- Two bacterial species were cultured from *Pomadasys stridens* (*Psychrobacter psychrophilus* and *Aeromonas species*).
- Two bacterial species were cultured from *Plotosus lineatus* (*Enterobacteriaceae* and *Aeromonas salmonicida*).
- Seven bacterial species were cultured from *Pempheris mangola* (*Shewanella baltica*, *Psychrobacter species, Arthrobacter species, Planococcus species, Planococcus species*, *Psychrobacter species* and *Bacillus species*).
- Three bacterial species were cultured from *Sardinella maderensis* (*Shewanella baltica*, *Shewanella baltica* and *Psychrobacter species*).
- Four bacterial species were cultured from *Lithognathus mormyrus* (*Shewanella baltica*, *Psychrobacter species*, *Psychrobacter cryohalolentis* and *Arthrobacter arilaitensis*).

- Seven bacterial species were cultured from *Liza aurata* (*Kocuria species, Kocuria palustris*, *Exiquobacterium species, Chryseobacterium*, *Psychrobacter faecalis, Psychrobacter species* and *Rothia species*).

Bacterial ID	**Bacterial Species**	**Blast-Match percentage %**	**Appearance**	**Relative Abundance**
1a	*Staphylococcus hominus*	99	White	+
1b	*Shewanella baltica*	98	cream-pink, jelly	++
1c	*Psychrobacter faecalis*	99	Cream	+++
2a	*Psychrobacter sp.*	94	Cream	++
2b	*Psychrobacter sp.*	99	Cream	++
2d	*Shewanella sp.*	99	cream-pink, jelly	++
2e	*Aeromonas salmonicida*	95	white beige	++
3a	*Psychrobacter faecalis*	99	Cream	+++
3b	*Planococcus sp.*	88	Orange	+
3c	*Psychrobacter faecalis*	99	Cream	+++
3d	*Shewanella putrefaciens*	96	cream-pink, jelly	++
3e	*Planococcus sp.*	99	Orange	+
3f	*Psychrobacter sp.*	97	Cream	+++
3g	*Arthrobacter sp.*	98	yellow, bright	+
4a	*Shewanella sp./ baltica*	97	cream-pink, jelly	++
4c	*Kocuria rhizophila*	88	yellow, bright	+
4e	*Psychrobacter sp.*	92	Cream	++
5a	*Psychrobacter maritimus/ sp.*	97	Cream	++
5b	*Planococcus sp.*	98	Orange	+
5c	*Shewanella baltica*	96	cream-pink, jelly	++
5e	*Psychrobacter sp.*	97	Cream	++
6a	*Psychrobacter cibarius/ immobilis*	90	Cream	++
6b	*Psychrobacter faecalis/ pulmonis*	97	Cream	++
6c	*Psychrobacter sp.*	79	Cream	++
6d	*Arthrobacter sp.*	95	Yellow	+
6e	*Psychrobacter sp.*	91	yellow, bright	+
7b	*Shewanella sp.*	97	cream-pink, jelly	++
7c	*Shewanella sp./ baltica*	98	cream-pink, jelly	++
7d	*Psychrobacter sp.*	96	Cream	++
8a	*Psychrobacter maritimus*	97	cream, jelly	++
8b	*Shewanella baltica*	99	cream-pink,	++

			jelly	
8c	*Psychrobacter faecalis/ pulmonis*	99	Cream	++
8d	*Psychrobacter faecalis/ pulmonis*	99	Cream	++
9a	*Shewanella putrefacien*	97	cream-pink, jelly	++
9b	*Vibrio metschnikovii*	91	cream, rough	++
9c	*Arthrobacter sp.*	96	Yellow	++
10a	*Psychrobacter psychrophilus*	97	Cream	+++
10b	*Aeromonas sp.*	98	cream, jelly	++
11a	*Serratia/ Enterobacteriaceae*	83	Cream	++
11b	*Aeromonas salmonicida*	99	Cream	++
12a	*Shewanella baltica*	95	cream, jelly	++
12c	*Psychrobacter sp.*	98	cream, jelly	++
12d	*Arthrobacter sp.*	97	yellow, bright	++
12e	*Planococcus sp.*	95	Orange	+
12f	*Planococcus sp.*	98	Orange	+
12g	*Psychrobacter sp.*	99	cream, jelly	++
12h	*Bacillus sp.*	99	Whitish	++
13a	*Shewanella baltica*	95	cream, jelly	++
13b	*Shewanella baltica*	97	cream, jelly	++
13c	*Psychrobacter sp.*	95	cream, jelly	++
14a	*Shewanella baltica*	87	cream, jelly	++
14b	*Psychrobacter sp.*	95	Cream	++
14c	*Psychrobacter cryohalolentis*	96	Cream	++
14d	*Arthrobacter arilaitensis*	97	yellow, bright	+
15a	*Kocuria sp.*	96	Yellow	+
15b	*Kocuria palustris*	95	Yellow	+
15c	*Exiquobacterium sp.*	96	Orange	+
15d	*Chryseobacterium/ Flavobacteriaceae*	97/94	mustard orange	+
15e	*Psychrobacter faecalis*	96	Cream	++
15g	*Psychrobacter sp.*	92	Cream	++
15h	*Rothia sp.*	99	mustard, light	+

Table 2. Bacterial species

C. Identification of non-cultivable bacteria:

After comparing both STE and Livak DNA extraction methods, we decided to use the latter one since it gave better results. After extraction, DNA was amplified then cloned using pGEM-T Easy vectors. Individual colonies that grew on plates were amplified again but unfortunately, this technique gave false positive results due to contamination of bacterial DNA from air.

D. Data Analysis:

R was used to show the frequency distribution of bacterial OTU's abundance and diversity among fish species. 38 different bacterial strains were unique (found in 1 fish only) while 1 bacterial strain was found in 3 and another in 7 different fish species respectively (Figure 2).

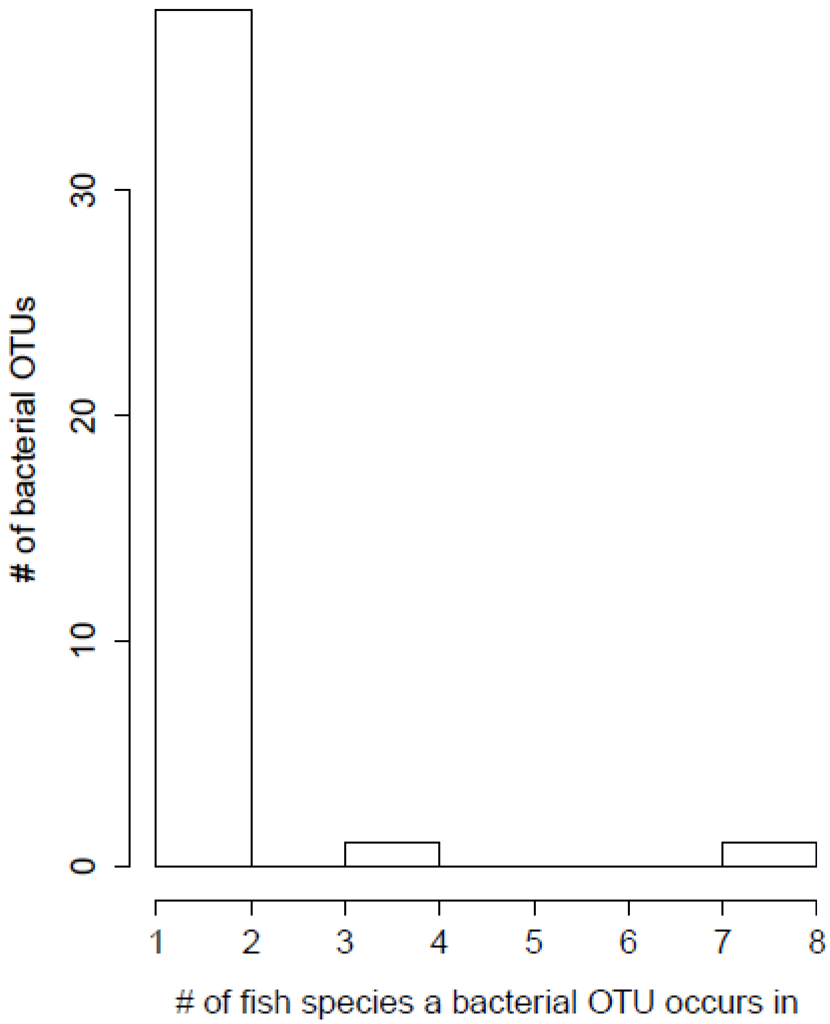

Figure 2. Frequency distribution of bacterial OTU abundance among wild caught fishes.

9 different fish specimens contained 2 bacterial strains, 2 fish specimens contained 3 bacterial strains, 2 fish specimen contained 5 bacterial strains, one fish specimen contained 4 bacterial strains and one fish specimen contained 6 bacterial strains (Figure 3).

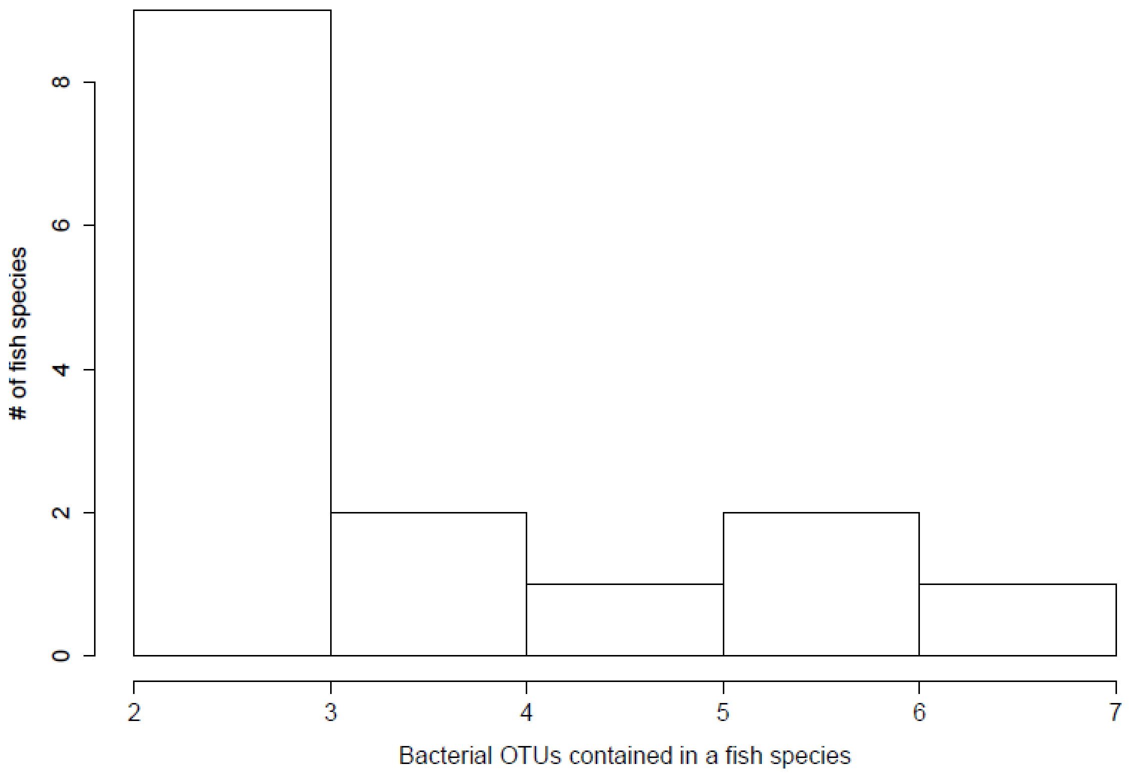

Figure 3. Frequency distribution of bacterial OTU diversity within fish species.

R was also used to detect whether bacteria obtained have a nested distribution pattern. Figure 4 shows that bacterial distribution is not nested and most of bacteria obtained are considered rare. Principal component analysis shows no strict clusters that coincided with any of the three fish categories (diet, swimming mode and origin). PCA shows that *Plotosus lineatus* and *Pomadasys stridens* and *Pagellus acarne* and *Pagellus erythrinus* have the same clustering position respectively. Furthermore, PCA shows that the 4 native fish species *Pagellus acarne*, *Pagellus erythrinus*, *Oblada melanura* and *Dentex macrophthalmus* form a cluster (Figure 6). There is no pattern describing the relationship between fish and their swimming mode (Figure 7). For example, *Liza aurata* and *Sardinella maderensis* are far away from each other. One reason for this might be that they were caught from different places where they might be eating different food.

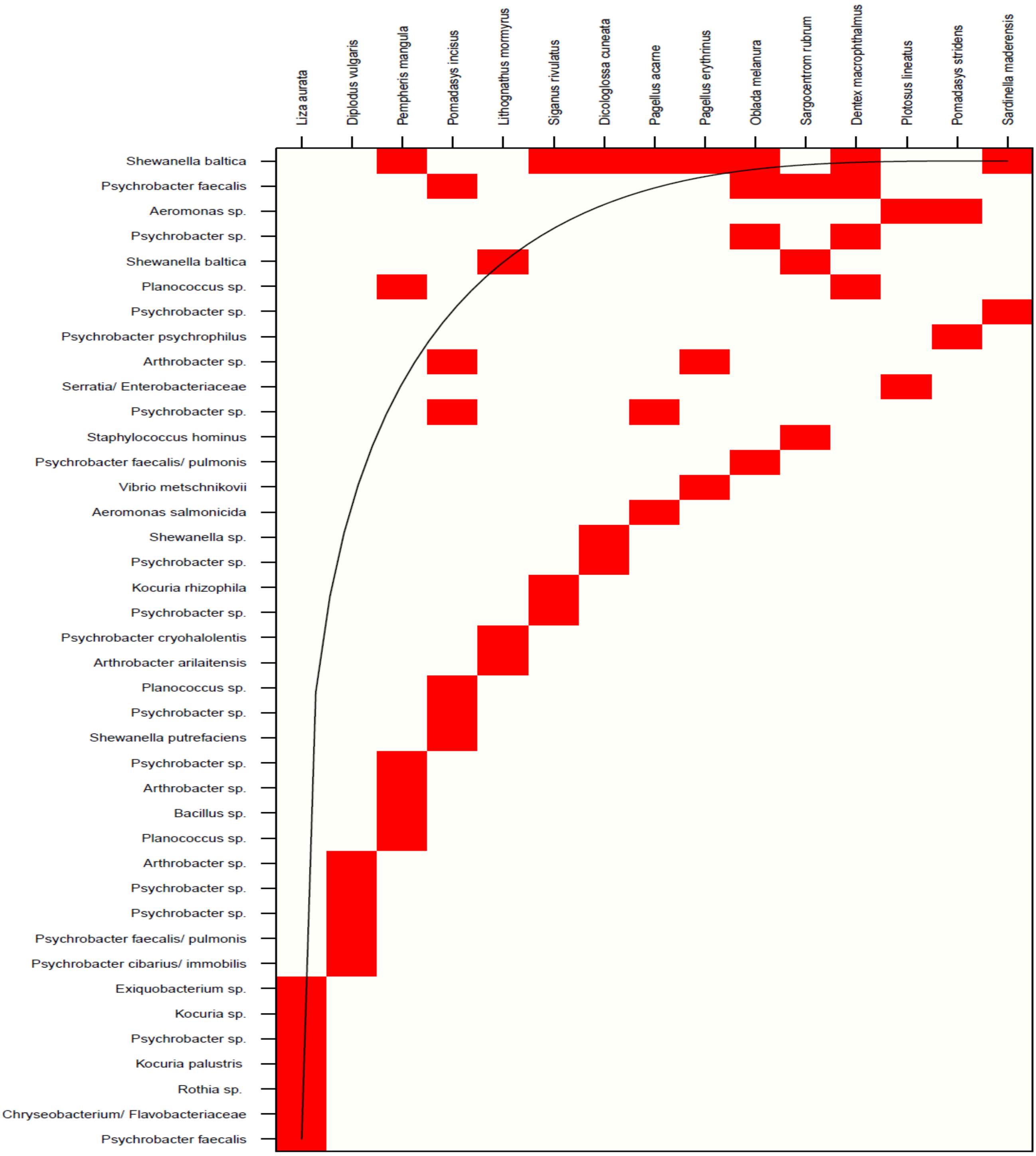

Figure 4. Nestedness analysis. Bacterial species are nestdess if the rarest strain is found in the most diverse fish. Bacterial strains are distributed from the most common to the rarest moving from the top of the figure to the bottom. Fish species however are distributed from the most diverse to the less diverse moving from the left to the right of the figure. The most diverse fish is *Liza aurata* containing 7 rare species while the most common bacteria is *Shewanella baltica* which is found in 8 fish species. Also, common bacterial species should be located on the left of the isocline. This analysis shows that most of the bacteria are rare. Thus, bacterial strains are not nested.

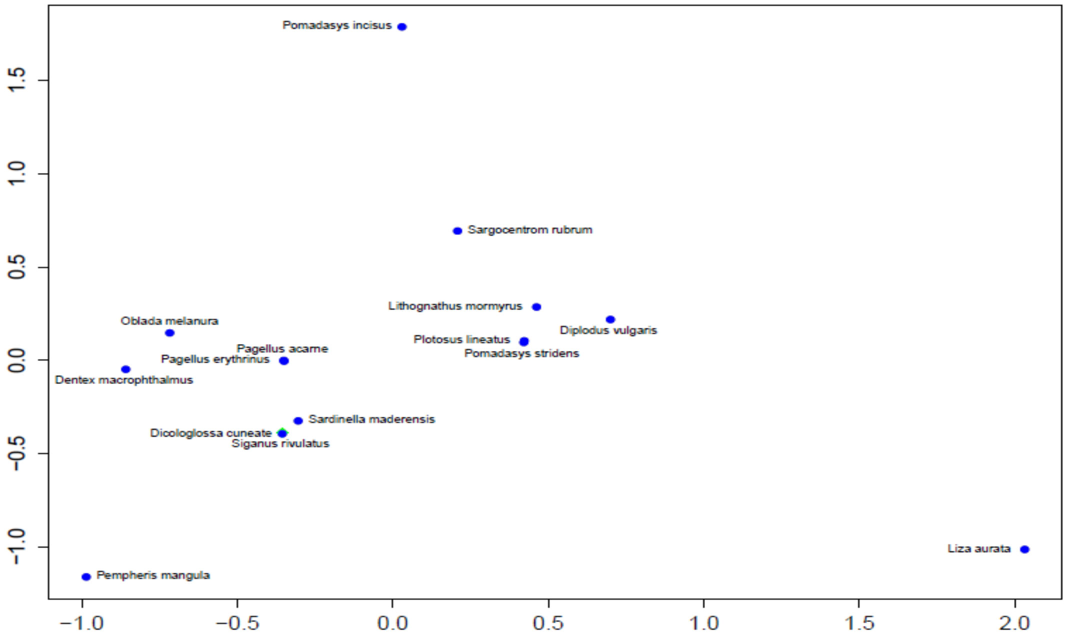

Figure 5. Multidimensional scaling of fish species. Species are colored according to their diet. Blue dots represent carnivorous species while the green dot represents herbivorous species. The green dot here representing *Siganus rivulatus* is masked with the blue dot of *Dicologlossa cuneate*.

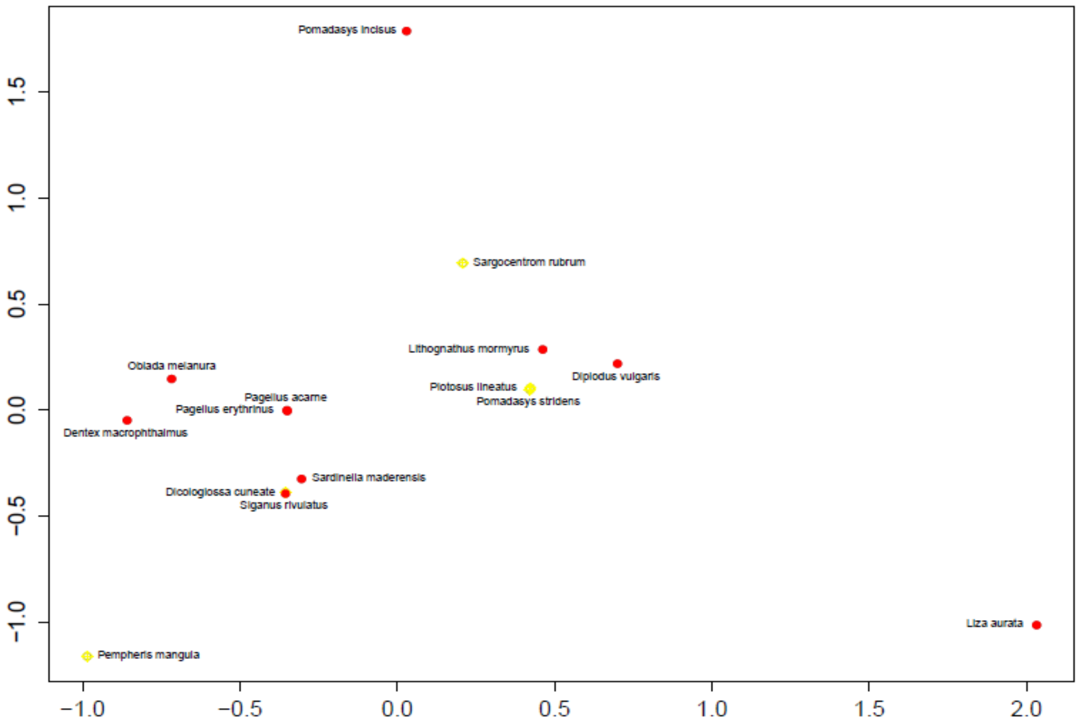

Figure 6. Multidimensional scaling of fish species. Species are colored according to their origin. The red dots represent native species while the yellow dots represent Lessepsian species. There is a relationship between 4 native fish species including *Pagellus acarne*, *Pagellus erythrinus, Oblada melanura* and *Dentex* macrophthalmus where they form a cluster.

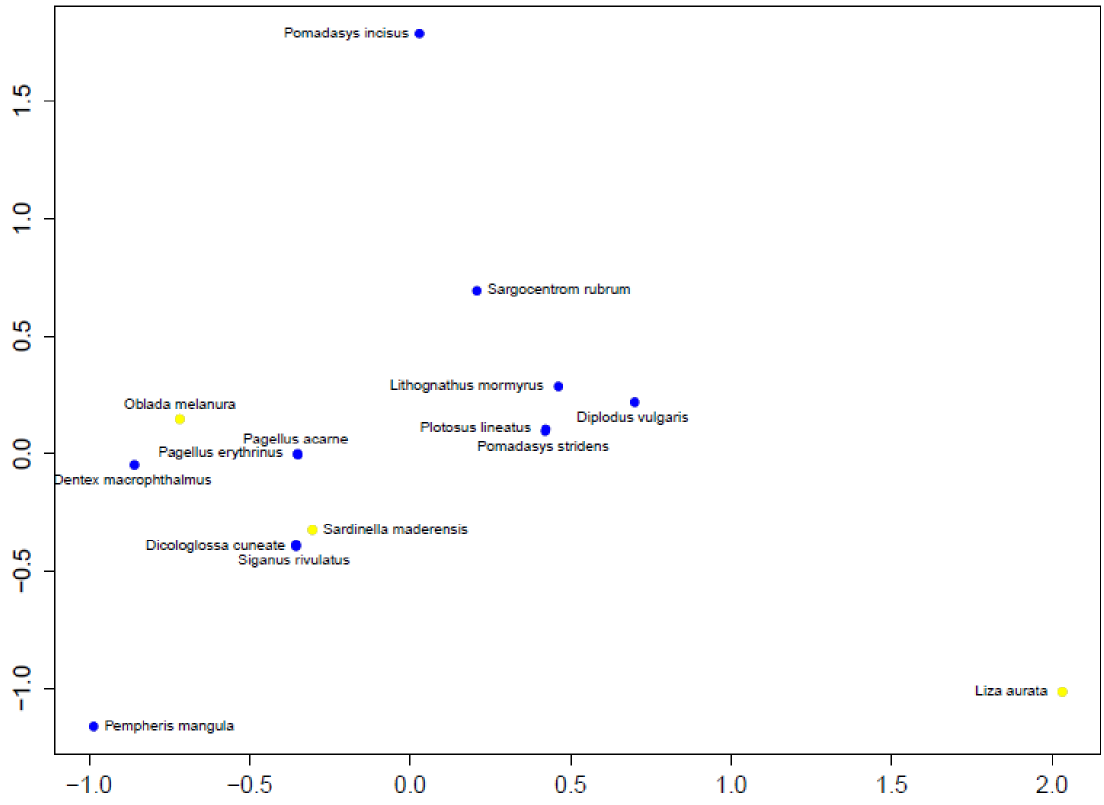

Figure 7. Multidimensional scaling of fish species. Species are colored according to their swimming mode. The yellow dots represent species that swim on the surface. The blue dots represent species that swim near the bottom.

E. Bacterial exposure:

To test the capacity of bacteria to colonize the gut of zebra fish (*Danio rerio*), we used a selection of the isolated bacteria that includes the following bacterial strains: *Aeromonas salmonicida, Planococcus species, Vibrio metschnikovii, Enterobacteriaceae, Kocuria palustris, Psychrobacter faecalis, Shewanella baltica, Arthrobacter species, Aeromonas salmonicida, Bacillus species, Exiquobacterium, Rothia species, Shewanella putrefacien, Planococcus species, Shewanella baltica, Psychrobacter cryohalolentis, Arthrobacter ariliatensis, Chryseobacterium, Psychrobacter faecalis, Shewanella putrefacien, Arthrobacter species, Psychrobacter maritimus, Aeromonas species, Kocuria species, Planococcus species, Kocuria* *rhizophila*, *Psychrobacter cibarius*, *Shewanella baltica*, *Psychrobacter psychrophilus* and *Aeromonas salmonicida.* After exposure to bacteria (see methods), we monitored the behavior of the fish. No lethality was observed. However, fish treated with *Kocuria palustris*, *Psychrobacter faecalis* and *Kocuria species* showed distress symptoms (abnormal swimming, rapid respiration) for 9 hours but they recovered afterwards.

Out of the 29 exposure experiments, we selected 10 bacterial strains to check whether they were able to resist host immunity and attach to the intestinal lining of zebra fish. Bacterial strains selected were: *Psychrobacter species, Shewanella species, Planococcus species, Psychrobacter species, Shewanella species, Psychrobacter species, Aeromonas species, Shewanella species, Psychrobacter species* and *Arthrobacter species*. We dissected one fish exposed to each bacterial species to isolate bacteria from its gut, sequence the obtained bacterial DNA and identify it using Blast technique. Four out of ten bacterial strains were able to colonize the intestinal lining of *Danio rerio* (Table 3).

Bacterial strain	**Ability of bacterial strain to persist**
Psychrobacter species	-
Shewanella species	+
Planococcus species	-
Psychrobacter species	-
Shewanella species	+
Psychrobacter species	-
Aeromonas species	-
Shewanella species	+
Psychrobacter species	-
Arthrobacter species	+

Table 3. Bacterial strains that resisted host's immunity. (+: resisted, -: didn't resist)

F. *Drosophila* Infection:

We wanted to assess the pathogenicity of these bacteria on the well-established *Drosophila* immunity model. For this, we injected a bacterial suspension of a known OD into the thorax of wild-type flies. Ability to cause lethality to the flies is summarized in Table 4.

Bacterial Species	**Ability to kill injected flies**
Staphylococcus hominus	-
Shewanella baltica	-
Psychrobacter faecalis	-
Psychrobacter sp.	-
Psychrobacter sp.	-
Psychrobacter faecalis	-
Planococcus sp.	-
Psychrobacter faecalis	-
Shewanella putrefaciens	-
Planococcus sp.	-
Psychrobacter sp.	-
Arthrobacter sp.	-
Kocuria rhizophila	-
Psychrobacter sp.	-
Psychrobacter maritimus/ sp.	-
Planococcus sp.	-
Psychrobacter sp.	-
Psychrobacter cibarius/ immobilis	-
Psychrobacter faecalis/ pulmonis	-
Psychrobacter sp.	-
Arthrobacter sp.	-
Psychrobacter sp.	-
Shewanella sp./ baltica	-
Psychrobacter sp.	-
Psychrobacter maritimus	-
Psychrobacter faecalis/ pulmonis	-
Psychrobacter faecalis/ pulmonis	-
Shewanella putrefacien	-
Vibrio metschnikovii	-
Arthrobacter sp.	-
Psychrobacter psychrophilus	-
Serratia/ Enterobacteriaceae	+
Aeromonas salmonicida	+/-
Psychrobacter sp.	-
Arthrobacter sp.	-
Planococcus sp.	-
Planococcus sp.	-
Psychrobacter sp.	-
Bacillus sp.	-
Psychrobacter sp.	-
Psychrobacter sp.	-
Psychrobacter cryohalolentis	-
Arthrobacter arilaitensis	-
Kocuria sp.	-
Kocuria palustris	-
Exiquobacterium sp.	-
Chryseobacterium/ Flavobacteriaceae	-
Psychrobacter faecalis	-
Psychrobacter sp.	-
Rothia sp.	-

Table 4. Ability to cause lethality to the injected flies (-: less than 30%, +/-: 50-90%, +: 100% death)

CHAPTER IV

Discussion

We have collected bacteria from the guts of 15 different fish species. After isolation of cultivable bacteria, we identified 61 bacterial species by sequencing their 16s ribosomal DNA and comparing the obtained sequences to bacterial genomic databases (NCBI nucleotide BLAST). We used statistical analysis in an attempt to determine whether the association of certain bacterial strains with their host-fish species were correlated to the habitat (pelagic versus benthic), diet (carnivorous, herbivorous or omnivorous) or origin (indigenous versus introduced) of the fish. A selection of the identified bacteria was used to assess the effects of these strains on two laboratory model organisms, *Danio rerio* (zebrafish) and *Drosophila melanogaster*. In agreement with previous reports (Nehme *et al*., 2007), *Serratia*, was highly pathogenic when injected into *Drosophila melanogaster*. We were also able to show that in 4 out of 10 cases the isolated bacteria was capable of colonizing the guts of zebrafish in laboratory conditions. We finally tried to identify the uncultivable bacterial species that are found in the fish guts by direct amplification of 16s DNA from guts content but this approach wasn’t pursued due to technical difficulties and lack of time.

Sample size and limitations:

In this pilot study, the number of fish species analysed was small (n=15) and only one specimen for each fish species was collected. In addition, although all the specimens were collected from the same fishing port, we can't be certain that they were caught from the same location. This is a limitation that hinders us from linking with confidence a given bacterial species to the fish life style and its environment.

Bacterial isolation:

Another important limitation was that this study focused only on the cultivable bacteria present in the fish guts. In addition, it is very likely that relying on visual differences in the colours and shapes for the isolation of bacterial colonies resulted in the non-selection of several bacterial species that appeared similar to the naked eye. This is due to our sampling/isolating technique since we took only one representative colony from each phenotype per plate to avoid picking several isolate of the same bacterial species from each fish specimen.

Possible improvements and perspectives:

Several facets of this work can be improved: one evident thing to do is to increase the sample size of wild-caught fish and to study more than one specimen for each fish species. Another added value would be to obtain several fish samples per species from different locations and at different seasons to determine whether these two parameters will be reflected on variations in the microflora. Finally, the results obtained could be compared to samples of the same fish species caught from different areas such as the Red sea.

Most of the bacteria that thrive in the digestive system of fish don’t grow on solid or liquid (artificial) media. Therefore, to have a better and more representative picture of gut flora, bacteria should be identified by the direct extraction of bacterial DNA from guts contents followed by 16s amplification and sequencing.

The exposure experiment showed that the isolated bacteria weren't accidentally present in the wild-caught fishes' guts since four of these isolates successfully colonized the gut of aquarium kept zebrafish. This is also an indication that these bacteria are adapted to live in the gut independently of whether the host is a freshwater or a seawater fish species.

Altogether, these preliminary results give a small overview of the bacterial species found in the guts of wild type fish living in Beirut seashore and can be considered a pilot or a feasibility study for a large scale project. With the above-mentioned improvements and additions, this analysis could consist a starting point to some experiments aimed at testing a potential utilisation of certain isolated bacteria in fish farming, since some may have a good impact on fish health by boosting growth and preventing harmful or pathogenic bacteria from colonizing the guts of farm raised fish species and ultimately increasing productivity. Another possible application would be the identification of certain bacterial species that can be used as indicator of polluted or poor water quality (residential sewage, garbage, oil spills etc…).

APPENDIX

I. Supplementary Tables:

Species	**Common Name**	**Fish ID**	**Bacterial ID**	**Bacterial Species**	**Weight (g)**	**Length (cm)**	**Weight of gut for plating (g)**	**Description of colonies on petri dish**	**Relative Abundance**	**Number of different colonies picked**
Sargocentrom rubrum	soldier fish	1	1a	Staphylococcus hominus	67.05	15.5	0.86	carpet + individual, colonies on top	+	grey carpet, white, pink, black only 2
			1b	Shewanella baltica					++	
			1c	Psychrobacter faecalis					+++	
Pagellus acarne	sea bream	2	2a	Psychrobacter sp.	47.64	14.9	1.56	a lot but not a carpet, almost	++	bright orange, grey, yellow, white, black white, pink
			2b	Psychrobacter sp.					++	
			2d	Shewanella sp.					++	
			2e	Aeromonas salmonicida					++	
Pomadasys incises	bastard grunt	3	3a	Psychrobacter faecalis	30.96	12.5	0.6	a lot but not a carpet, almost	+++	grey carpet, bright orange(a lot), black, white, yellow, pink, yeast like (white/cream-pink)
			3b	Planococcus sp.					+	
			3c	Psychrobacter faecalis					+++	
			3d	Shewanella putrefaciens					++	
			3e	Planococcus sp.					+	
			3f	Psychrobacter sp.					+++	
			3g	Arthrobacter sp.					+	
Siganus rivulatus	rabbit fish	4	4a	Shewanella sp./ baltica	65.47	17.1	3.5	individual colonies	++	very small yellow, big cream-pink, white, pearl white, yeast white, transparent
			4c	Kocuria rhizophila					+	
			4e	Psychrobacter sp.					++	
Dentex macrophthalmus	large eye dentex	5	5a	Psychrobacter maritimus/ sp.	30.61	13	0.74	carpet, grey + colonies on top	++	white/grey, cream-pink, bright pink, pearl white, bright orange
			5b	Planococcus sp.					+	
			5c	Shewanella baltica					++	
			5e	Psychrobacter sp.					++	

Diplodus vulgaris	two banded sea bream	6	6a	Psychrobacter cibarius/ immobilis	37.97	13.1	1.02	carpet, grey + colonies on top	++	white, carpet, white/cream-pink, bright orange, 1-2 small yellow, black(center of the colony)
			6b	Psychrobacter faecalis/ pulmonis					++	
			6c	Psychrobacter sp.					++	
			6d	Arthrobacter sp.					+	
			6e	Psychrobacter sp.					+	
Dicologlossa cuneate	sole	7	7b	Shewanella sp.	49.06	16.3	1.99	carpet, grey + colonies on top	++	grey carpet, white, white/cream-pink, bright and small orange
			7c	Shewanella sp./ baltica					++	
			7d	Psychrobacter sp.					++	
Oblada melanura	saddled sea bream	8	8a	Psychrobacter maritimus	91.71	18.9	0.92	carpet, grey + colonies on top	++	pink, white/pink, carpet, white irregular shape (yeast like)
			8b	Shewanella baltica					++	
			8c	Psychrobacter faecalis/ pulmonis					++	
			8d	Psychrobacter faecalis/ pulmonis					++	
Pagellus erythrinus	Pandora	9	9a	Shewanella putrefacien	19.71	10.1	0.5	no carpet, individual colonies	++	yellow, cream-pink/white irregular big, white round
			9b	Vibrio metschnikovii					++	
			9c	Arthrobacter sp.					++	
Pomadasys stridens	striped piggy	10	10a	Psychrobacter psychrophilus	71.71	16.4	1.12	carpet +individual	+++	carpet, white/cream-pink
			10b	Aeromonas sp.					++	
Plotosus lineatus	cat fish	11	11a	Serratia/ Enterobacteriaceae	21.43	14.8	1.34	carpet +individual	++	carpet, white/pink, 1-2 bright orange
			11b	Aeromonas salmonicida					++	
Pempheris mangola	sweeper	12	12a	Shewanella baltica	49.93	15.5	0.8	almost no carpet, individual	++	bright orange, yellow, white, white/cream-pink
			12c	Psychrobacter sp.					++	
			12d	Arthrobacter sp.					++	
			12e	Planococcus sp.					+	
			12f	Planococcus sp.					+	
			12g	Psychrobacter sp.					++	

			12h	Bacillus sp.					++	
Sardinella maderensis	sardine	13	13a	Shewanella baltica	12.57	11.7	0.34	carpet on big plate, individual	++	pink, carpet, white
			13b	Shewanella baltica					++	
			13c	Psychrobacter sp.					++	
Lithognathus mormyrus	sand Steenbras	14	14a	Shewanella baltica	25.5	11.9	0.45	carpet on big plate, individual	++	pink, 2-3 yellow, white, white/cream-pink
			14b	Psychrobcter sp.					++	
			14c	Psychrobacter cryohalolentis					++	
			14d	Arthrobacter arilaitensis					+	
Liza aurata	mullet	15	15a	Kocuria sp.	171.51	26.8	6.87	no carpet, individual colonies	+	small pink, yellow, irregular(yeast like) cream-pink
			15b	Kocuria palustris					+	
			15c	Exiquobacterium sp.					+	
			15d	Chryseobacterium/ Flavobacteriaceae					+	
			15e	Psychrobacter faecalis					++	
			15g	Psychrobacter sp.					++	
			15h	Rothia sp.					+	

ST 1. First batch of wild-caught fish.

Species	Common Name	Fish ID	Bacterial ID	Weight (g)	Length (cm)	Weight of gut for plating (g)	Description of colonies on petri dish	Relative Abundance	Number of different colonies picked
Pagellus erythrinus	pandora	16	16a	47.03	14.9	1.09	a lot but not a carpet, almost		mixed, white, pinkish
			16b					+	
			16c					+++	
Diplodus vulgaris	two banded sea bream	17	17a	42.64	13.9	0.83	a lot but not a carpet, almost	+	white, pinkish
			17b					+++	
Siganus revulatus	rabbit fish	18	18a	102.58	23.6	5.02	carpet + individual, colonies on top	+++	yellow
Oedalechilus labeo	mullet	19	19a	288.45	31.2	7.9	a lot but not a carpet, almost	+	white, pinkish, orange, whitish, yellow
			19b					+++	
			19c					+	

			19d					++	
			19e					+	
Pagellus erythrinus	pandora	20	20a	52.79	15.3	1.2	carpet + individual, colonies on top	+++	pinkish, pearl white, yellow/orange
			20b					+	
			20c					+	
Diplodus vulgaris	two banded sea bream	21	21a	39.97	13.6	0.35	a lot but not a carpet, almost	+++	pinkish, yellow, white
			21b					+	
			21c					++	
Siganus revulatus	rabbit fish	22	22a	105.64	19.8	7.23	a lot but not a carpet, almost	+++	grey/pink, white
			22b					+++	
Oedalechilus labeo	mullet	23	23a	219.2	28.8	8.83	a lot but not a carpet, almost	+++	pinkish, white, yellow/orange
			23b					+++	
			23c					+	

ST 2. Second batch of wild-caught fish.

Species	**Common name**	**Weight (g)**	**Intestinal weight (g)**
Siganus revulatus	rabbit fish	66.98	12.7
Dentex macrophthalmus	large eye dentex	15.81	0.19
Diplodus vulgaris	two banded sea bream	39.20	0.82
Sparidae	sparid	22.10	0.93
Sparidae	sparid	14.70	0.89
Sparidae	sparid	10.20	0.44
Siganus revulatus	rabbit fish	71.25	5.17

ST 3. Third batch of wild-caught fish.

II. 16s sequences

1a, *Staphylococcus hominus*:

CAATCATTTGTCCCACCTTCGACGGCTAGCTCCAAATGGTTACTCCACCGGCTTCGGGTGTTACMAAYTYTCGTGGTG
TGACGGGCGGTGTGTACAAGACCCGGGAACGTATTCACCGTAGCATGCTGATCTACGATTACTAGCGATTCCAGCTTC
ATGTAGTCGAGTTGCAGACTACAATCCGAACTGAGAACAACTTTATGGGATTTGCTTGACCTCGCGGTTTCGCTGCCC
TTTGTATTGTCCATTGTAGCACGTGTGTAGCCCAAATCATAAGGGGCATGATGATTTGACGTCATCCCCACCTTCCTCC
GGTTTGTCACCGGCAGTCAACTTAGAGTGCCCAACTTAATGATGGCAACTAAGCTTAAGGGTTGCGCTCGTTGCGGG
ACTTAACCCAACATCTCACGACACGAGCTGACGACAACCATGCACCACCTGTCACTTTGTCCCCCGAAGGGGAAACT
TCTATCTCTAGAAGGGTCAAAGGATGTCAAGATTTGGTAAGGTTCTTCGCGTTGCTTCGAATTAAACCACATGCTCCA
CCGCTTGTGCGGGTCCCCGTCAATTCCTTTGAGTTTCAACCTTGCGGTCGTACTCCCCAGGCGGAGTGCTTAATGCGTT
AGCTGCAGCACTAAGGGGCGGAACCCCCTAACACTTAGCACTCATCGTTTACGGCGTGGACTAC

1b, *Shewanella baltica*:

TTAACGRCKGGGCGGCAGGCCTAACACATGCAAGTCGAGCGGCAGCGGGAAGATAGYTTRCTATCTTTGCCSGCGAG
CGGCGGACGGGTGAGTAATGCCTAGGGATCTGCCCAGTCGAGGGGGATAACAGTTGGAAACGACTGCTAATACCGC
ATACGCCCTACGGGGGAAAGGAGGGGACCTTCGGGCCTTCCGCGATTGGATGAACCTAGGTGGGATTAGCTAGTTGG
TGAGGTAATGGCTCACCAAGGCGACGATCCCTAGCTGTTCTGAGAGGATGATCAGCCACACTGGGACTGAGACACGG
CCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAWKGGGGGAAACCCTGATGCAGCCATGCCGCGTGTG
TGAAGAAGGCCTTCGGGTTGTAAAGCACTTTCAGTAGGGAGGAAAGGTARYAGCTTAATACGCTGTTGCTGTGACGT
TACCTACAGYRGAAGGACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTCCGAGCGTTAATCGGAATT
ACTGGGCGTAAAGCGTGCGCAGGCGGTTTGTTAAGCGAGATGTGAAAGCCCCGGGCTCAACCTGGGAATTGCATTTC
GAACTGGCGAACTAGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAKMSGGTGAAATGCGTAGAGATCTGGAGG
AATACCGGGTGGCG

1c, *Psychrobacter faecalis*:

AGAACGCTGASMGGCAGGCTTAACACMTGGRAKYCSAGSGGWAACRRGRGAAGCTTGCTTCYCGSTGACGAGCGGC
GGACGGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACG
ACCTACGGGAGAAAGGGGGCARCTTGYTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGWTGGTGGGGTA
AAGGCCTACCAWGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGA
CTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGA
AGGCCTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTG
CAGAATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGG
CGTAAAGCGAGCGTAGGTGGCTTRATAAGTCAGATGTGAAAGCCCCGGGCTTAACCTGGGAACGGCATCTGATACTG
TTAGGCTAGAGTAGGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGG

2a, *Psychrobacter* sp.:

GGTGAAMGMCTTCCSGAAAGGTTAGGCTATCCACTTCTGGTGGATAAAACCGGAGGRGTGACGGGCGGTGTGTACA
AGGCCCGGGAATGCATTAACCGCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTTCATGGAGTCGAGTTGCAGA
CTCCAATCTGGACTACGATAGGCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCCCTCTGTACCTACCATTGTAG
CACGTGTGTAGCCCTGGTCGTAAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCTCCAGTTTGTCACTGGCAGTA
TCCTTAKAGTTCCCGGCTTAACCCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTC
ACGACACGAGCTGACKACTGTCTTGYAGMACCTGTATTCTAATTCCCGAAGGCACTCCCGCATCTCTGCRGGATTCTA
GATATGTCAAGACCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGT
CAATTCWTTTGAGTTTTAACCTTGCGGCCGTACTCCCCASGCGGYCTACTTATTGCGTTAGCTGCGTCACTAAGTCCCT
CAAGGGACCAACGACTAGTAGACATCSTTTACGGYGTGGACTACCMRGGGTATCTAATCCTGTTTGCTACCCACGCT
YTTCCAACCCTCAGTGTCCAATATGGATGCCMGAAAGCTGGCCTTTCGCCCATCGGGTATTY

2b, *Psychrobacter* sp.:

GTTAGGCTATCCACTTCTGGTGCAAYCAACTCCCATGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCA
CCGCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTTCATGGAGTCGAGTTGCAGACTCCAATCTGGACTACGAT
AGGCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCCCTCTGTACCTACCATTGTAGCACGTGTGTAGCCCTGGTC
GTAAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCTCCAGTTTGTCACTGGCAGTATCCTTAGAGTTCCCGGCTT
AACCCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGCTGACGAC
AGCCATGCAGCACCTGTATTCTAATTCCCGAAGGCACTCCCGCATCTCTGCAGGATTCTAGATATGTCAAGACCAGGT
AAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTA
ACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTATTGCGTTAGCTGCGTCACTAAGTCCTCAAGGGACCCAACGACTA
GTAGACATCGTTTACGGCGTGGACTACCAGGGTAT

2d, *Shewanella* sp.:
GTGTGARCGMCCCCCCGAAGGTTAAGCTACCCACTTCTTTTGCAGCCCMYTYCCATGGTGTGACGGGCGGTGTGTAC
AAGGCCCGGGAACGTATTCACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAG
ACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCATTGT
AGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGCAG
TCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAACATT
TCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCASAGTTCCCGAAGGCACTAAGCTATCTCTAGCGAATTC
TCTGGATGTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCC
GTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGAGAGCCCAGTG
TTCAAGACACCAAACTCCGAGTAGACATCGTTTACGGCGTGGACTACCAGGGTATC

2e, *Aeromonas* sp.:
CCCTACCGACAGAATCAACCGMGGTAACGMCCTCCCCAAGTTAAGCTATCTACTTCTGGGAAGAAACCCATGGTGTG
ACGGGCGGTGTGTACAAGGCCCGGGAAGAATTCAMCGCGACATTCTGATTCGCGATTACTAGCGATTCCGACTTCAC
GGAGTCGAGTTGCAGACTCCGATCCGGACTACGACGCGCTTTTTGGGATTCGCTCACTATCGCTAGCTTGCAGCCCTC
TGTACGCGCCATTGTAGCACGTGTGTAGCCCTGGCCGTAAGGGCCATGATGACTTGACGTCATCCCCACCTTCCTCCG
GTTTATCACCGGCAGTCTCCYTTGAKTTCCCACCATTACSTGCTGGCAACAAAGGACAGGGGTTGCGCTCGTTGCGGG
ACTTAACCCAACATCTCACGACACGAGCTGACGACAGCCATGCAGCACCTGTGTTCTGATTCCCGAAGGCACTCCCS
WATCTCTWSRGGATTCCAGACATGTCAAGGCCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCAC
CGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCGATTTAACGCGTT
AGCTCCGGAAGCCACGTCTCAAGGACACAGCCTCCAAATCGACATCGTTTACGGCGTGGACTACCAGGGTATCTAAA
TCCTGTTTGCTCCCCACGCTTTCGCACCTGAGCGTCAGTCTTTGTCCMAGGGGGGCCGCCTTCGCCACCCGGTATTY
CCTCCCAGAATCTCTACGCATTTCACCCGCTACACCCTGGAAATTCCTACCCCCCCCTCTACAAGAACTTCTWAGCT
GGGAMAGTTTTAAAATTGACAAATTCCCYCARGKTKKGAAGAGTACT

3a, *Psychrobacter faecalis*:
GCCACACYGTGGTGAGCGMCATCCTAAAAGGTTAGGCTACCCACTTCTGGTGCAATCMAYTCCCATGGTGTGACGGG
CGGTGTGTACAAGGCCCGGGAACGTATTCACCGCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTTCATGGAGT
CGAGTTGCAGACTCCAATCTGGACTACGATAGGCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCCCTCTGTAC
CTACCATTGTAGCACGTGTGTAGCCCTGGTCGTAAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCTCCAGTTTG
TCACTGGCAGTATCCTTAGAGTTCCCGGCCAAACCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGCGGGACTTA
ACCCAACATCTCACGACACGAGCTGACGACAGCCATGCAGCACCTGTATTCTAATTCCCGAAGGCACTCCCGCATCTC
TGCAGGATTCTAGATATGTCAAGACCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGT
GCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTATTGCGTTAGCTGCGT
CACTAAGTCCTCAAGGGACCCAACGACTAGTAGACATCGTTTACGGCGTGCACTACCAGGGTA

3b, *Planococcus* sp.:
GGGGGGGACGGGSGGGGGWACAAGGCCCGGRAACGTATTCMCCGKGSMATGCTGATCCACAATTACAASCGATTC
CAGCTTCATGCAKGCAAGTTGCAACCTACAATCCGAACTGAAAAGGGTTTTCTGGRATTGSYTCCCCCTCSSGSKTTGS
MRACCCTTTGTACCGYCCATTGWASCASGTGTGTASCCCAGGTCATAAGGSGCATGATGATTTGACGTCATCCCCACC
TTCCTCCGGTTTGTCACCGGCRGTCACCTTARAGTGCCCAAMTGAATGCTGGSAACTAAAATCAAGGGTTGCGCTCGT
TGCGGGACTTAACCCAACATCTCACGACMCSAGCTGACSACCACCATGCACCACCTGTCACCACTGTCCCCGAAGGG
AAAAGTGTATCTCTACRCCGGKCASWGSRATGTCAAGACCTGKWAAGGTTCTTCSSGTTGYTYCRAATTAAACCACAT
GCTCCACCGCTGGTGCGGSCCCCCGTCAATTCCTTTGAGTTTMASCCTTGCGGCCGTACTCCCCAGGCGGAGWGCTTA
ATGCGTTAGCTGCAKCACTAAGTGCGCRGAGACCCCMTMACACTTAKSACTCAKCGTTTAGGYGTGCACTACCAGGA
TATCTAATCCTGTTTGCTCCCCACGYTTCRCGCCTCAGCGTCAGTTACAKMMCCAGTARAGT

3c, *Psychrobacter faecalis*:
AGAAGCTTGCTTCTCGCTGACGAGCGGCGGACGGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTC
GGGGAAACTCGAATTAATACCGCATACGACCTACGGGAGAAAGGGGGCAACTTGTTGCTCTCGCTATTAGATGAGCC
TAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGC
CACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCT
GATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTT
AATACCCATGGACGATGACATTAGCTGCAGAATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGG
GTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGAGCGTAGGTGGCTTGATAAGTCAGATGTGAAAGCCCCGGGC
TTAACCTGGGAACGGCATCTGATACTGTTAGGCTAGAGTAGGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAA
ATGCGTAGAGATCTGGAGGAATACCGATGGCGAAGCAGCTTCTGGCATCATACTGACACTGAGGTTCGAAAGCGTGG
GTAGCAAACAGGATTAGATACCCYKGGTAGT

3d, *Shewanella putrefaciens*:
CCGCACCTTACTTTTGAGGGGAAAGGGGGTAARSGYGACGGGGGGGAAAGGCCGGAAGAAAASGRRAGGGCATTCT
GATCCACGATWACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAGACTCCAATCCGKACTACGACGAGCTTTGTGA
GATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCA
TGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGMAGTCTCTCTAGAGTTTCCACCATTACGTGCTGGC
AAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAACATTTCACAACACGAGCTGACGACAGCCAGGCAGC
ACCTGTCTCACGGTTCCCGAAGGYACTAAGTTTTCTCTAGCGAATTCCGYGGATGYCAAGAGTAGGTAAGGTTCTTCK
CGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTSAGTTCTAACCTTGCGGSCG
TACTCCCAGGCGGYCTACTTAATGYTTAGYTTGAA

3e, *Planococcus* sp.:
GGGTTACCTCACCGACTTCGGGTGTTACWWAYTCTCGTGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATT
CACCGTGGCATGCTGATCCACGATTACTAGCGATTCCGGCTTCATGCAGGCGAGTTGCAGCCTACAATCCGAACTGA
GAACGGTTTTCTGGGATTGGCTCCCCCTCGCGGGTTGGCAACCCTTTGTACCGTCCATTGTAGCACGTGTGTAGCCCA
GGTCATAAGGGGCATGATGATTTGACGTCATCCCCACCTTCCTCCGGTTTGTCACCGGCAGTCACCTTAGAGTGCCCA
ACTGAATGCTGGCAACTAARATCAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGCTGACG
ACAACCATGCACCACCTGTCACCACTGTCCCCGAAGGGAAAAGTGTATCTCTACACCGGGCAGTGGGATGTCAAGAC
CTGGTAAGGTTCTTCGCGTTGCTTCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCCTTTGAGT
TTCAGCCTTGCGGCCGTACTCCCCAGGCGGAGTGCTTAATGCGTTAGCTGCAGCACTAAGGGGCGGAAACCCCCTAA
CACTTAGCACTCATCGTTTACGGCGTGACTACCAGGTATCTAATCCTGTTTGCTCCCCACGCTTCGCGCCTCAGCGTCA
GTTACAGACCAG

3f, *Psychrobacter* sp.:
TGGTGAACGCTCCCCCGAAGGTTAAGCTATCCACTTCTGGTGCAATAACACMSRKGGTGTGACGGGCGGTGTGTACA
AGGCCCGGGAACSTATTCACCGCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTTCATGGAGTCGAGTTGCAGA
CTCCAATCTGGACTACGATAGGCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCCCTCTGTACCTACCATTGTAG
CACGTGTGTAGCCCTGGTCGTAAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCTCCAGTTTGTCACTGGCAGTA
TCCTTAGAGTTCCCGGCTTAACCCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTC
ACGACACGAGCTGACGACAGCCATKYWKYWYYTGTATTCTAATTCCCGAAGGCACTCCCGCATCTCTGCAGGATTCT
AGATATGTCAAGACCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCG
TCAATTCATTTGAGTTTTAACCTTGCGGCGTACTCCCCAGGCGGTCTACTTATTGCGTTAGCTGCGTCACTAAGTCCTC
AAGGGACCCAACGACTAGTAGACATCGTTACGGCGTGACTACCAGGGTATCTAATCCTGTTTGCTACCCACGCTTTCG
AGCCTCAGTGTCAGTATTTAWTGCCAGRAA

3g, *Arthrobacter* sp.:
GATCCCACCGTTCGACGACTMCCTCCRCMCAAGGTGGTTAGGCCATCGGCTTCGGGYGTAMCCAACTTTCGTGACTT
GACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGCAGCGTTGCTGATCTGCGATTACTAGCGACTCCGACTT
CATGGGGTCGAGTTGCAGACCCCAATCCGAACTGAGACCGGCTTTTAGGGATTAGCTCCACCTCACAGTATCGCAAC
CCATTGTACCGGCCATTGTAGCATGCGTGAAGCCCAAGACATAAGGGGCATGATGATTTGACGTCATCCCCACCTTCC
TCCGAGTTGACCCCGGCAGTCTCCCATGAGTCCCCACCTTTACGTGCTGGCAACATGGAACGAGGGTTGCGCTCGTTG
CGGGACTTAACCCAACATCTCACGACACGAGCTGACGACAACCATGCACCACCTGTGAACCAGCCCCGAAGGGAAA
CCCCATCTCTGAGGCGGTCTGGAACATGTCAAGCCTTGGTAAGGTTCTTCGCGTTGCATCGAATTAATCCGCATGCTC
CGCCGCTTGTGCGGGCCCCCGTCAATTCCTTTGAGTTTTAGCCTTGCGGCCGTACTCCCCAGGCGGGGCACTTAATGC
GTTAGCTACGGCGCGGAAAACGTGAATGTTCCCCACACCTAGTGCCCACGTTTACGGCATGACTACCAGGTATCTAAT
CCTGTTCGCTCCCATGCTTTCGCTCCTCAGCGTCAGTAGATGCCCAGAG

4a, *Shewanella* sp.:
CMGCTCATGAACCACAAAGTGGTGAGCGCCCCCCCGAAGGTTAAGCTACCCACTTCTTTTGCAGCCCACTCCCATGG
TGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACT
TCATGGAGTCGAGTTGCAGACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAAC
CCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCT
CCGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGC
GGGACTTAACCCAACATTTCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCACRGTTCCCGAAGGCACW
MMKSTATCTCTASYGRMTTCYGTGGATGTCAAGRGKWRGGKWAAGGTTCTTCGCGTTGCATCGAATTAAACCACAT
GCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAA
TGCGTTAGCTTGAGAGCCCAGTGTTCAAGACACCAAACTCCGAGTAGACATCGTTTACGGCGTGACTACCAGGTATCT
AATCCTGTTTGCTCCCACGCTTCGTGCCTGAGCGTCAGTCTTTGTCCAGGGGGCCGCC

4c, *Kocuria rhizophila*:
AGGGTTAGGCCACCGGCTTCGGGKGTTAAAACASKSGKGRCTTGACGGGSGGKGKGTACAAGGCCCGGGAACGTATT
CACCGCRGCGTKGYTGATCTGCRATWACTAGCRACTCCGAYTTCWCGTGGYCRAKTTGCARACCACRATCCRAAYTG
ARACSAGTTTTTTGGRATTAGYTCCMCCTCSCGGYWTCSCAACCCATTGTMCTGGCCWTTGTAGCATGSGKGAAGCC
CARGACATARGGGGMATGAKGATTTGACGTCWTCCCCMCCTTCCTCCGAGTTGACCCSGGCRGTCTCCTATGAGTCC
CCACCATCASGTGCTGGCWACATAKAACGAGGGTTGCGCTCGTTGCGGKACTTAACCCAWCATCTCACGACACGAGC
TGACRACAACCATGCACCACCTGTACACCAGCCCCACAAGGGGGAAAGACCATCTCTGGCCCGGTCCGGTGTATGTC
AAGCCTTGGTAAGGTTCTTCGCGTTGCATCKAATTAATCCGCATGCTCCGYCGCTTGTGCGSSCCCCCGTCAATTCCTT
TGAGTTTTAGSCTTGCGGMCGYACTCCSCAGGCGGGKYACTKAATGCGTTAGCTACGGCRCGGCAAGAMRTGGTMAT
GWTCCCCACACCTAGTGCCYAWCGTGTACGGCATGCACTRCTATGATATCTARTCCTGYTCGCTCCYYATGCTTTCGC
TCCTCAGCGTTCAGTAACCAGCCCAG

4e, *Psychrobacter* sp.:
CACATGCGTTCCGGGGTAACCTTAACATGGGATCCCGGGGGCTTGGTTCCCGGTTGAMCTCAGGAGTCMARCGCCGS
KCGGGSGAGTAATACTTAKGAATCTACCTAGYARTGGGGGATAGCTCGGGRAAACTCGAATTAATACCGCATACRAC
CTACGGKAGAAAGGGGGCAACTTGTTGCTCTCGCTATTAGATGAGCCTAAGYCGGATTAGCTAGAYGGTGGGGTAAA
GGCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACMCCGGGACTGAGACACRGCCCGGACTC
CTACGGGAGGCAGSAGYGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGG
CCTTTTGSTTGTAAAGCACTTTAAGCASCGAAKAAKACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCMGA
ATAAGCACCGGCTAACTTGGYGCCAGCRGCCGCGGTAATACASAGGGTGCAAGCGTTAATCGGAATTACTGGGGSGY
AAAGCGAGCGTASGTGGCTTGATAAGWCAGATGWGAAAACCCCGGGCTTWAACCTGGGAACTGCATCTGATACTGT
TAGGYTAGAATAGKYGAGAGGGAAGGTAGAAATCCCACGGCGTAG

5a, *Psychrobacter maritimus*:
ACMACCATGCAAGTCGAGCGGAAACGATGATAGCTTGCTAYCAGGCSYCGAGCGGCGGACGGGTGAGTAATACTTA
GGAATCTACCTAGTAGKGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGGGRGAAAGGGGG
CAACTTGTTGCTCTCGCTATTARATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCATGGCGACG
ATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAGGCAGCAGT
GGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGKGKGTGAAGAAGGCCTTTTGGTTGTAAAGCA
CTTTAAGCAGTGAAGAAGACTCCRTGGTTAATACCCAYGGACGATGACATTAGCTGCAGAATAAGCACCGGCTAACT
CTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGSGAGCGTAGGTGGC
TTGATAAGTCAGATGTGAAATCCCCGGGCTTAACCTGGGAACTGCATCTGATACTGTTAGGCTAGAATAGGTGAGAG
GAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGGCGAAAGCAGCCTTCTGG
YATCATATTGACACTGAGGTTCGAAAGCGTGGTAGCARACAGGATTAGATACCCTGGTAGTCCMCGCCGYAACGATG
TCTACTAGTCGTTGGGTCCTTGAGACTAATGACGCMGCTAMMSMATAAGTAGACCSCCTGGGRTACGCGCAGGTAAC
TCAATGATGWCGGGGCCGCCAGCGTGRCATKGTTAATTCATGCACSSGAGAAACATAAYG

5b, *Planococcus* sp.:
GGCGGCGTGCCTAATACATGCAAGTCGAGCGGAACCAGAGGAGCTTGCTCCTTCTGGTTTAGCGGCGGACGGGTGAG
TAACACGTGGGCAACCTGCCCTGCAGATCGGGATAACTCCGGGAAACCGGTGCTAATACCGAATAGTTTGCGGCCTC
TCCTGAGGCTGCACGGAAAGACGGTCTCGGCTGTCACTGCAGGATGGGCCCGCGGCGCATTAGCTAGTTGGTGGGGT
AATGGCCTACCAAGGCGACGATGCGTAGCCGACCTGAGAGGGTGATCGGCCACACTGGGACTGAGACACGGCCCAG
ACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCGCAATGGACGAAAGTCTGACGGAGCAACGCCGCGTGAGTGACG
AAGGTTTTCGGATCGTAAAACTCTGTTGTGAGGGAAGAACAAGTGCCAACTAACTACTGGCACCTTGACGGTACCTC
ACCAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGCAAGCGTTGTCCGGAATTATTGGG
CGTAAAGCGCGCGCAGGCGGTTCTTTAAGTCTGATGTGAAAGCCCACGGCTCAACCGTGGAGGGTCATTGGAAACTG
GAGAACTTGAGTACAGAAGAGGAAAGTGGAATTCCATGTGTAGCGGTGAAATGCGTAGAGATGTGGAGGAACACCA
GTGGCGAASGCGACTTTCTGGTCTGTAACTGACGCTGAGGCGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCT
GGTAGTCCACGCCGTAAACGATGAGTGCTAAGTGTTAGGGGGGTTTCCGCCCCTTAGTGCTGCAGCTAACGCATTAA
GCACTCCGCCCTGGGGAGTACGGGCGCAAGGGCTGAAACTCAAAGGGATTGACGGGGCYCGCMCAAGGCGKTGGAA
GCAAKGKKGATTTTAAAATTTCG

5c, *Shewanella baltica*:

CAAAGTGGTGAGCGCCCCCCCGAAGGTTAAGCTACCCACTTCTTTTGCAGGAAACCCGTGGTGTGACGGGCGGTGTG
TACAAGGCCCGGGAAGAATTCACCGKGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTG
CAGACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCAT
TGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGG
CAGTCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAAC
ATTTCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCACRGTTCCCGAAGGCACTAAGYTATCTCTAGCGA
ATTCYSTGGATGTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGC
CCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGAGAGCCC
AGTGTTCAAGACACCAAACTCCGAGTAGACATCGTTTACGGCGTGGACTACCAGGGTATCTAATCCTGTTTGCTCCCC
ACGCTTTCGTGCCTGAGCGTCAGTCTTTGTCCAGGGGGGCGCCTTCGCCACCGGGTATTCCTCCAGATCTCTACGCAT
TTCACCGCTACACCTGGAATTCTACCCYCCCTCTACAAGACTCTAGTTCGCCMRGTTCGAAATGGMATTYCCCAGGTT
GAAGCCGGGGGATTTTCMCATCTTCGCTTAAACCAAAACCGGCCTKGCGCACCRGCTTTTTAMRCSCCCACRCAWA
AATTYTC

5e, *Psychrobacter* sp.:

CMGATCATCACCACACCGTGGTGAACGCTCCCCCGAAGGTTAAGCTATCCACTTCTGGTGCAATCMMYTYCCATGGT
GTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTT
CATGGAGTCGAGTTGCAGACTCCAATCTGGACTACGATAGGCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCC
CTCTGTACCTACCATTGTAGCACGTGTGTAGCCCTGGTCGTAAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCT
CCAGTTTGTCACTGGCAGTATCCTTAGAGTTCCCGGCTTAACCCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGC
GGGACTTAACCCAACATCTCACGACACGAGCTGACGACAGCCATGCAGCACCTGTATTCTAATTCCCGAAGGCACTC
CCGCATCTCTGCAGGATTCTAGATATGTCAAGACCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCC
ACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTATTGCGT
TAGCTGCGTCACTAAGTCTCAGGGACCAACGACTAGTAGACATCGGTTACGCGTGACTACAGTATCTATCTGTTGCTA
CCACGCTTCGAGCTCATGTCAGTATATGCCAGAGGCT

6a, *Psychrobacter cibarius*:

GGYTTTTCCTTCCGGCTCGCCCGAKGCGGCGGGACGGGKTGGAGTAAWACTTTAGGAAATCCTACCCTAGKAAGTGG
GGGGATAGCACGGGAAACTCGTATTTAATACCGCATACGACTACGGGAGAAAGGGGGGCAGTTACTGCTCTCGCTAT
TTAATGAGCCTAAKCGGATTASTAGATGGKGGGGGAAAGGGCCTACCTGGGSAACAATCTGWASTGGGYCTGAAAG
GATGATCASCCCCCCCGGGACTGAAACCCGGCCCGGACTCTACGGGGAGGMRGMRKGGGGGAAATATTGGAACAAT
GGGGGGAAAACCCTGGATCCRSCCATGGCCGCGKGGKGKGAAGAAAGGCCTTTTTGGGTTGTAAAAGCACTTTTAAG
CAGTGAAAGAAAGACTCCCRTGGGTTAATACCCCATGGGACGATGACTTTAGCTGCAGAATAAGCACCGGCTAACTC
TGTGCCAGCAGCCGCGGGTAATACAGAGGGTGCAAAGCGTTAATCGGAATTACTGGGCGTAAAGGGAGCGTAGGTG
GCTCTATAAGTCAGATGTGAAATCCCCGGKCTTAAYCTGGGAACTGCATCTGAAACTGTAGAGCTAGAGTATGTGAG
AGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGGCGAAGGCAGCCTTCT
GGCATAATACTGACACTGAGGCTCGAAAGCGTGGGTAGCAACAGGATTAGATACCCTGGTAGTCCACGCCGTAACGA
TGTCTACTAGTCGTTGGGTCCCTTGAGGACTTAGTGACGCAGCTAACGCAATAAGTAGACCGCCTGGGGGAGTACGG
GCCGCAAGGTTAAACTCAAATGAATTKGACGGGGGCC

6b, *Psychrobacter faecalis*:

TAAACGCCTGGCGGCAGGCTTAACACATGCAAGTCGAGCGGTAACAGGAGAAGCTTGCTTCTCGCTGACGAGCGGCG
GACGGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGA
CCTACGGGAGAAAGGGGGCAACTTGTTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGKGGGGTAA
AGGCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACT
CCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAG
GCCTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCRTGGTTAATACCCATGGACGATGACATTAGCTGCAR
AATAAGCMCCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGT
AAAGCGAGCGTAGGTGGCTTGATAAGTCAGATGTGAAAGCCCCGGGCTTAACCTGGGAACGGCATCTGATACTGTTA
GGCTAGAGTAGGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATG
GCGAAGGCAGCCTTCTGGYATCATACTGACACTGAGGTTCGAAAGCGTGGGTAGCAACAGGATTAGATACCCTGGKA
GTCCACGCCGYAACGATGTCTACTAGTCGTTGGGTCCTTGARGACTTAGTGACSCASCTMACGCATAGTAGACCGCCY
GGGGAGTACAGCCGCAARGTAACTCMATGATTGWCGGGGCCGCCACGTGGACMTKGTATTCATGCAC

6c, *Psychrobacter* sp.:

TGACGCTGGCGGCAGGCTTAACACATGCAAGTCGAGCGGAAACGATGATACTTGCTATCAGCGTCGAGCGGCGGACG
GGTGARTAATACTTAGGAATTACCTAGTAGTGGGGGATAGCTTCGGGGATACTCAAMTATACCGCATACGACCTACG
GGAGAWWGGGGGCAACTTCTTCGCCTCTCCCATCCAATCARCCCTGTCGGATAGCTAGTTTGTGGGGTAYTGGCCTA
CCTGGCGACATTTTTAKCTGGTTTAAARGTTTATTASCTACTCGGGACTTAAACACGGCTGGACTTTTACGGGAGGCA
GCAGTGGGGATTCTGGACATTGGGGGCAYCTTTGATTTAGCCATTCCGCGTGTTTTAWGAYGGCCCCCCTGTGTATAG
CACCCCTGCAGTGATGCTGCCCTTACTGTTTAACTTATGGACGKTACATCTKTTCARYTAYGCACCGGCTAYCCTTTTC
CAGCAGCCGCGGTTTTTCAGTGGGTTCAAGCTTTAATCGGAATCATTGGGCGTAAAGCGAGCGTAAGTTGGTTCGTAA
GTCAKCCGMGAAACCCCCGGGTTCAACCTCTGGYATCGCTCTCGWMATCTTCGGTCTGWRAWKGCGYGTGGRWGG
MGYRYWCTCMGGTGTMGCGGTGTRACGCTARAGWACCMGGWGGWKAMACSACKGCGAAAGCAGCCTYYCCGGY
AKCWAMACGRCAYCGAKGTACGAATGCRTGGGTAKCAGCTGACGGACTCCGKAKTYACTCCTAAACAAGRYAACAT
CTTTKGTTCTCGAGGAMCATGACMTTCAMSTAATAGACCTCGTGACKGCATGAAGCATGAMCGTGTSAACGTGACGT

6d, *Arthrobacter* sp.:

GGGCGGCGTGCTTACACATGCAAGTCGAACGATGACCCCGTGCTTGCACGGGTGATTAGTGGCGAACGGGTGAGTAA
CACGTGAGTAACCTGCCCCTGACTCTGGGATAAGCCCGGGAAACTGGGTCTAATACTGGATATGACCTTTAACCGCA
TGGTTTTTGGTGGAAAGATTTATCGGTTGGGGATGGACTCGCGGCCTATCAGCTTGTTGGTGAGGTAATGGCTCACCA
AGGCGACGACGGGTAGCCGGCCTGAGAGGGTGACCGGCCACACTGGGACTGAGACACGGCCCARACTCCTACGGGA
GGCAGCAGTGGGGAATATTGCACAATGGGCGAAAGCCTGATGCAGCGACSCCGCGTGRGGGATGACGGYCYTCCGG
GTTKTAAACCTYTTTCAGTAGGGAAGAAGCGAAAGTGRCGGGTACCCTGCAGAARAAAGCGCCGGSCTAACTACKTG
CCAGSMRGCCGSSGGTAAATACGTAAGGSGRARSGYTTTYYCCGKATTTTATTGGGSMRAAAARASCTCMWARGSSK
TTTTSCCSSYCKYGCCRWAAAWYCMAGRGYMCCMCCCCMRAYTYGGGGGGGSMSGGSAAAMWWRGWGGWTGGG
GGGAAWGTGATTTYYSKGKGTRASSGRAAWGCCMAAWTWYMGGGGRAMMCCCTGTGMARGSGGSTCTKGGGCYY
TYWYGASCKAGAGAGAGARYTKGRGAAAAAAAAGAATAAACACCYGYGAGACCCKSGSCAAACGTTGGMCTMTGT
GGGGAAATMYCRTGTTCGCGCGTCTACTATMGTATTACGCCCCCTGTGAT

6e, *Psychrobacter* sp.:

TGGGCGGGSAGGCTTAACACATGCAAGTCGAGCGRAAACSMYGAKMKCKTGCTATCAGGATYRKCGAGCGGCGGAC
GGGTGAGTAATACTTARGAATCTACCTAGTAKGGGGGGATAGCTCGGGRAAACTCSWATTAATACCGCAKACSACCT
ACSGGAGAAAGGGGGCWACTTGKTGCTCTCGCTWTTAGATGAGCCTAAGTCGGATTAGCTAGATGGKGGGGTAAAG
GCCTACCATGGCGACGATCTGTAGCTGGTCTGARAGGATGATCAGCCMCMCCGGGACTGARACMCGGCCCGGACTC
CTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGG
CCTTTTGGTTGTAAAGCACTTTAMGCAGTGAARAAGACTCCATGGTTAATACCCRTGGACGATGACATTAGCTGCASA
ATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCRAGCGTTAATCGGAATTACTGGGCGTA
AAGCGAGCGYAGGKGGMTTGATAAGTCARATGTGAAATCCCCGGKSTTAACCTGGRAACTGCATCTGATWCTGTTAG
GCTRGAATAGGTGAGAGRAAGGTAGAATTKCCAGGTGTAGCGGWGAAATGCSTAKAGATCTGGAGGAATACCGATG
GYSAASGSAGCCTTCTGGCATCATATTGACACTGAGGWTCGAAAGCGTGASTMKGRACAGGATTASATACCCTGGTA
GTCCACGSCGTRACGATGTCTACTAGTYTYGSGTCCCTTGWRGASYTATTGACGCMCCYYACYSGATAAGWMGACCS
CTGGGKARTACYGCCGCSMAKGTAGAGCTCAMYGMAATGACGGGACCGCCAGCRTTGAGCMWGSGTTAATCWATG
CAACGCGGRRAAAGA

7b, *Shewanella* sp.:

AAACGCCCTYYCGAAGGTTAAGCTATSTACTTCTGGTGCAGGAACCCATGGKGTGACGGGCGGTGTGTACAAGGCCC
GGGAAGATTCACCGKGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAGACTCCAATC
CGGACTACGACAAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTTGCCATTGTAGCACGTGT
GTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGCAGTCTCCCTAA
AGTTCCCACCATTACGTGCTGGCAAATAAGGATAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATTTCACAACA
CGAGCTGACGACAGCCATGCAGCACCTGTCTCAGAGYTCCCGAAGGCACTAARCYATCTCTRGCRAATTCTCTGGAT
GTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATT
CATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGRGAACCCAGTGTTCAAGA
CACCAAATTCCGAGTAGACATCGTTTACGGCGTGGACTACCAGGGTATCTAATCCTGTTTGCTCCCCACGCTTTCGTA
CCTGAGCGTCAGTCTTTGTCCAGGGGGCCGCCTTCGCCACCGGTATTCCTTCAGATCTCTACGCATTTCACCGCTACAC
CTGAAATTCTACCCCCCTCTACAAGACTCTAGTYTGCCAGTTCGAAATGCARTTCCCAGGGTTGAGCCCGGGGGCTTC
ACATCTCGCTAACAAACCGTCCTGGCGTACCGCCTTTTTACGSCCCCCRAGTTAAT

7c, *Shewanella baltica*:
CMGATCATGACCACAAAGTGGTGAGCGCCCCCCCGAAGGTTAAGCTACCCACTTCTTTTGCAGCCCMYTCCCARGGT
GTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTT
CATGGAGTCGAGTTGCAGACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACC
CTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTC
CGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCG
GGACTTAACCCAACATTTCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCACRGTTCCCGAAGGCACTAM
KSTATCTCTASYGAATTCYSTGGATGTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCA
CCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTT
AGCTTGAGAGCCCAGTGTTCAAGACACCAAACTCCGAGTAGACATCGTTTACGGCGTGACTACCAGGTATCTATCCT
GTTTGCTCCCCACGCTTTCGTGCCTGAGCGTCAGTCTTTGTCCAG

7d, *Psychrobacter* sp.:
GAGGAAAGGGGAGGKGTGACGGGGGGTGACAGGCGGGAARAAAARGRGRRCGGCATTCTGATCCGCGATTACTAGC
GATTCCTACTTCATGGAGTCGAGTTGCAGACTCCAATCTGGACTACGATAGGCTTTTTGAGATTCGCATCACATCGCT
GTGTAGCTGYYCTCTGTACCTACCATTGTAGCACGTGTGTAGCCCTGGTCGTAAGGGCCATGATGACTTGACGTCGTC
CCCGCCTTCCTCCAGTTTGTCACTGGCAGTATCCTTAKAGTTCCCGGCTTAACCCGCTGGTAACTAAGGACAAGGGTT
GCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGCTGACGACAGCCATGCAGCACCTGTATTCTAATTCCC
GAAGGCACTCCCGCWTCTCTGCAGGATTCTAGATATGTCAAGACCAGGTAAGGTTCTTCGCGTTGCATCGAATTAAA
CCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCCTTGCGGCCGTACTCCCCAGGCGGT
CTACTTATTGMGTTAGCTGCGTCACTAAGTCCTCAAGGGACCCAACGACTAGTAGACATCGTTTACGGCGTGGACTA
CCAGGGTATCTAATCYTGTTTGCTACCACGYTTTCRAACCTCAGTGYCAATATGATGCCAGAAGGCTGCCTTCGCCAT
CCGGGATTCCCTCCAGATCTCCTACGCATTTCACCSGCTWMCACCKGAAATTCTWCCTTYCCTCCTCACCMTATTCW
AGCCTAMACAGATATSCAKAATGGCRKCTCCCARGATTAAGGCCCCGGGGCAWTT

8a, *Psychrobacter maritimus*:
TAGGCTATCCACTTCTGGTGCAAYCMAYTCCCATGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACC
GCGGCATTCTGATCCGCGATTACTAGCGATTCCTACTTCATGGAGTCGAGTTGCAGACTCCAATCTGGACTACGATAG
GCTTTTTGAGATTCGCATCACATCGCTGTGTAGCTGCCCTCTGTACCTACCATTGTAGCACGTGTGTAGCCCTGGTCGT
AAGGGCCATGATGACTTGACGTCGTCCCCGCCTTCCTCCAGTTTGTCACTGGCAGTATCCTTAGAGTTCCCGGCTTAA
CCCGCTGGTAACTAAGGACAAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGCTGACGACAG
CCATGCAGCACCTGTATTCTAATTCCCGAAGGCACTCCCGCATCTCTGCAGGATTCTAGATATGTCAAGACCAGGTAA
GGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACC
TTGCGGCCGTACTCCCCAGGCGGTCTACTTATTGCGTTAGCTGCGTCACTAAGTCCTCAGGGACCCAACGACTAGTAG
ACATCGTTTACGCGTGACTACAGGTATCTATCCTGTTGCTACCACGCTTCGACTCAGTGTCATATGATGCAGAGCTGC
TTCGCATCGGTA

8b, *Shewanella baltica*:
GGTTAAGCTACCCACTTCTTTTGCASCCCACTCCCATGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCA
CCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAGACTCCAATCCGGACTACGAC
GAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACTC
GTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCACCAT
TACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAACATTTCACAACACGAGCTGACGAC
AGCCATGCAGCACCTGTCTCACGGTTCCCGAAGGCACTAAGCTATCTCTAGCGAATTCCGTGGATGTCAAGAGTAGG
TAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTA
ACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGAGAGCCCAGTGTTCAAGACACCAAACTCCGA
GTAGACATCGTTTACGGCGTGTACTACCAGGTATCTAATCCTGTTTGCTCCCCACGCTTTCGTGCCTGAGCGTCAGTCT
TTGTCCAGGGGGGCSGCCTTC

8c, *Psychrobacter faecalis*:
CGGCAGGCTTAACACATGCAAGTCGAGCGGTAACAGGAGAAGCTTGCTTCTCGCTGACGAGCGGCGGACGGGTGAG
TAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGGGAG
AAAGGGGGCAACTTGTTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCA
TGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAG
GCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGGTT
GTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGAATAAGCACC
GGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGAGCG
TAGGTGGCTTGATAAGTCAGATGTGAAAGCCCCGGGCTTAACCTGGGAACGGCATCTGATACTGTTAGGCTAGAGTA
GGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGAGATACGATGCGACGCAGCTTCTG
GCATCATACTGACACTGAGTTCGAAGSGTGGGTAGCAAA

8d, *Psychrobacter pµlmonis*:
GACGCCTGGCGGCAGGCTTACACATGCAAGTCGAGCGGTAACAGGAGAAGCTTGCTTCTCGCTGACGAGCGGCGGAC
GGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCT
ACGGGAGAAAGGGGGCAACTTGTTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGG
CCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCT
ACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCC
TTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGAA
TAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAA
AGCGAGCGTAGGTGGCTTGATAAGTCAGATGTGAAAGCCCCGGGCTTAACCTGGGAACGGCATCTGATACTGTTAGG
CTAGAGTAGGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGGC
GAAGCAGCCTTCTGGCATCATACTGACACTGAGGTTCGAAAGCGTGGGTAGCAAACAGGATTA

9a, *Shewanella putrefaciens*:
AGGTTAAGCTACCCACTTCTTTTGCAGCCCACACCCARGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATT
CACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAGACTCCAATCCGGACTACG
ACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTA
CTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCAC
CATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAACATTTCACAACACGAGCTGAC
GACAGCCATGCAGCACCTGTCTCASAGTTCCCGAAGGCACTAAGCTATCTCTAGCGAATTCTSTGGATGTCAAGAGTA
GGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTT
TTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGAGAGCCCAGTGTTCAGACACCAACTCCG
AGTAGACATCGTTTACGGCGTGTACTACCAGGTATCTATCCTGTTTGCTCCCACGCTTCGTGGCTGACGTCAGTCTTTG
TCAGGGGCGCTCGCACGGTATTCTCAGATCTTCTAC

9b, *Vibrio metschnikovii*:
AAGGAAGCTTGCTTTCTTTGCTGACGAGCGGCGGACGGGTGAGTAATGCCTGGGAAATTGCCCTGATGTGGGGGATA
ACCATTGGAAACGATGGCTAATACCGCATGATGCCTACGGKYCTAAKAAGGGGACCTTCGGGCCTCTCACCGCARGG
TCTGTCCMGGYGGGATTAGCTAGKTGGKGAGGWAATGGYTCRCCARGGMRAGGATCCCTARSTGGACTGASAGGAT
GAGCASTCACACTGKAACTGASCCCCCTGCCACACTCCTACGGKAGGSASTCCTGCGGAATATTGCACWGTGGAAGM
TWGCCTGATGCRSSCATGCCTGGTGYATGAATAASGCCTGCRTGATGAAAAGCTCTTTCWKGCRAGAGGAAGGCGGT
ATCGWTAATAGSGGTATTCTTTGACGTTRGMTTCTTAGAARKYACCGACTAACTACGYGCCRGCTRMCTCCGTGATA
CSGAGGGYGCKAGCGTTRATCGTAATTACTGKRATCRRAGTTACTGCASGTGRWTTGYWAAGTCAKATGTGGAAGCC
CGGGACTCAACCTCSCGAGTTSTCTTTGAMACTGKYRSGTTAGAGTACTGYAGASTRGAGTAGAATTTARGGTGTWAG
AATTTCATGYGTAGAGATCTAATGSGAAWACCRKCTGGARAAAATACCGCTG

9c, *Arthrobacter* sp.:
AGGTGGTTAGGCCATCGGCTTCGGGTGTMYYCAACTTTCGTGACTTGACGGGCGGTGTGTACAAGGCCCGGGAACGT
ATTCACCGCAGCGTTGCTGATCTGCGATTACTAGCGACTCCGACTTCATGGGGTCGAGTTGCAGACCCCAATCCGAAC
TGAGACCGGCTTTTAGGGATTAGCTCCACCTCACAGTATCGCAACCCATTGTACCGGCCATTGTAGCATGCGTGAAGC
CCAAGACATAAGGGGCATGATGATTTGACGTCATCCCCACCTTCCTCCGAGTTGACCCCGGCAGTCTCCCATGAGTCC
CCACCTTTACGTGCTGGCAACATGGAACGAGGGTTGCGCTCGTTGCGGGACTTAACCCAACATCTCACGACACGAGC
TGACGACAACCATGCACCACCTGTGAACCAGCCCCGAAGGGAAACCCCATCTCTGAGGCGGTCTGGAACATGTCAAG
CCTTGGTAAGGTTCTTCGCGTTGCATCGAATTAATCCGCATGCTCCGCCGCTTGTGCGGGCCCCCGTCAATTCCTTTGA
GTTTTAGCCTTGCGGCCGTACTCCCCAGGCGGGGCACTTAATGCGTTAGCTACGCGCGGAAACGTGGAATGTTCCCAC
ACCTAGTGCCACGTTACGCATGACTACAGGTATCTATCCTGGTCGCTCCCATGCTTCGCTCCTCAGCGTCAGTAGATG
CCAGAGACTGCCTTCCGCCATCGGGGTTCCTCCTGGAWWTCTTG

10a, *Psychrobacter psychrophilus*:
GGCTTAACACATGCAAGTCGAGCGGAAACGATGATAGCTTGCTATCAGGCGWCGAGCGGCGGACGGGTGAGTAATR
CTTRGGAAWCTRCCTAGTRGTGGGGGATAGCTCSGGGAAACTCGAATTAATACCGCATACGACCTACGGGAGAAAGG
GGGCAACTTGTTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGKGGGGTAAAGGCCTACCATGGCG
ACRATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAGGCAGC
AGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCMTGCCSCGTGKGTGAAGAAGGSCTTTTGGTTGTAAA
GCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGAATAAGCACCGGCTA
ACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGAGCGTAGGT
GGCTTGATAAGTCAGATGTGAAATCCCCGGGCTTAACCTGGGAACTGCATCTGATACTGTTAGGSTAGAATAGGTGA
GAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGGCGAAGGCAGCCTTC
CTGGCATCATATTGACACTGAGTTCGAAGCGKGGGTAGCAAMAGGATTA

10b, *Aeromonas* sp.:

GGGCGGGCRGGCCTAACACATGCAAGTCGAGCGGCAGCGGGAAAGTAKCTTGCTAYTTTTGCCGGCGAGCGGCGGA
CGGGTGAGTAATGCCTGGGGATCTGCCCAGTCGAGGGGGATAACAGTTGGAAACGACTGCTAATACCGCATACGCCC
TACGGGGGAAAGGAGGGGACCTTCGGGCCTTTCGCGATTGGATGAACCCAGGTGGGATTAGCTAGTTGGTGGGGTAA
TGGCTCACCAAGGCGACGATCCCTAGCTGGTCTGAGAGGATGATCAGCCACACTGGAACTGAGACACGGYCCAGACT
CCTACGGGAGGCAGCAGKGGGGAATATTGCACAATGGGGGAAACCCTGATGCAGCCATGCCGCGTGTGTGAARAAG
GCCTTCGGGTTGTAAAGCACTTTCAGCGAGGAGGAAAGGTTGGCGCCTAATACGTGTCAACTGTGACGTTACTCGCA
RAARAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTACTGGGCG
TAAAGCGCACGCAGGCGGTTGGATAAGTTAKATGTGAAAGCCCCGGGCTCAACCTGGGAATTGCATTTAAAACTGTC
CAGCTAGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGGT
GGCGAAGCGGCCCYCTGGACAAAGACTGACGCTCAKGTGCGAAAGCGTGGGG

11a, Enterobacteriaceae:

AACTGCCTGATGGAGGGGGATAACTACTGGAAACGGKAGCTAATACCGCATAACGTCTTCRGACCAAAGKGGGGGA
CCTTCGGGCCTCRCSCCMTCAKATGTGCCCAGATGGGATTATCTARTAGGKGGGGTAATGTCTCACCTASGCGACRAT
CCCTATSTGGTCTGAGARGATGACCASCCACWCTGRAACTGACACACSCCCCACACTCCTACGGGGGGSARCWGTGG
GGAATATTGCACAGTGSGCGCAMGCCTGATGCACCCATGCCGCGTGTGRGAARAAGGCCTTCGGGKTGTAAAGCACT
TTCWKCGARGAGGAAGGGKASRGTGKTAATASCYCTCTGYWGTGACRWTACTCRCAGAARAAACACCSTCTMTCTC
CGTGCCAKCASSCGCGGTAATACAGAGGGTGCKWGCGTTWWGCASAATTACTGSGCGTARAGCGCACGCRCGSGGT
GTGWTAAGTCAKATGTGATATCCKCKCKCTCACGTGGGMWCTGYWTTTGA

11b, *Aeromonas salmonicida*:

TACGGCTGGGCGGCAGGCCTAACACATGCAAGTCGAGCGGCAGCGGGAAAGTAGCTTGCTACTTTTGCCSGCGAGCG
GCGGACGGGTGAGTAATGCCTGGGGATCTGCCCAGTCGAGGGGGATAACAGTTGGAAACGACTGCTAATACCGCAT
ACGCCCTACGGGGGAAAGGAGGGGACCTTCGGGCCTTTCGCGATTGGATGAACCCAGGTGGGATTAGCTAGTTGGTG
GGGTAATGGCTCACCAAGGCGACGATCCCTAGCTGGTCTGAGAGGATGATCAGCCACACTGGAACTGAGACACGGTC
CAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGGGGAAACCCTGATGCAGCCATGCCGCGTGTGTG
AAGAAGGCCTTCGGGTTGTAAAGCACTTTCAGCGAGGAGGAAAGGTTGGCGCCTAATACGTGTCAACTGTGACGTTA
CTCGCAGAAGAAGCACCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTAATCGGAATTAC
TGGGCGTAAAGCGCACGCAGGCGGTTGGATAAGTTAGATGTGAAAGCCCCGGGCTCAACCTGGGAATTGCATTTAAA
ACTGTCCAGCTAGAGTCTTGTAGAGGGGGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGATAC
CGGTGGCGAAGCGGCCCCCTGGTACAAGACTGACGCTCAGKGCGAAAGCGTGGGGAGCAAAC

12a, *Shewanella baltica*:

GCCACAAAGTGGTGAGCGCCCCCCCSMAGGTTAAGCTACCCACTTCTTTTGCAGCCCWMMACMMARGGTGTGACGG
GCGGTGTGTACAAGGCCCGGGAACGTWTTCACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGA
GTCGAGTTGCAGACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGT
ACTCGCCATTGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTT
TATCACCGGCAGTCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACT
TAACCCAACATTTCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCACRGTTCCCGAAGGCACTMMKSTAT
CTCTASYGRATTCYGTGGATGTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCT
TGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTT
GAGAGCCCAGTGTTCAGACACCAAACTCCGAGTAGACATCGTTTACGCGTGACTACCAGGTATCTATCCTGGTGCTCC
CACGCTTCGTGCTGAACGTCAGTCTTTGTCAGGGCGGCTTCGCACCGGGTATTCCTCCAGATYTTYTACG

12c, *Psychrobacter* sp.:

CGGCAGGCTTAACACATGCAAGTCGAGCGGAAACGATGGTAGCTTGCTACCAGGCGTCSMYCGGCGGACGGGTGAG
TAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGGGAG
AAAGGGGGCAGTTTACTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCA
TGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAG
GCAGCAGTGGGGAATATTGGACAATGGGGGAAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGGTT
GTAAAGCACTTTAAGCAGTGAAGAAGACTCCGTGGTTAATACCCACGGACGATGACATTAGCTGCMGAATAAGCAC
CGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGGGAGC
GTAGGTGGCTCGATAAGTCAGATGTGAAATCCCCGGGCTCAACCTGGGAACTGCATCTGATACTGTTGAGCTAGAGT
ATGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGYGAAATGCGGTAGAGATCCTGGAGGAATACCGATTGGTGAA

12d, *Arthrobacter* sp.:

GGATGACCCCGTGCTTGCACGGGTGATTAGTGGCGAACGGGTGAGTAACACGTGCGTACCTGCCGTGATTTKGTAGG
TTGTTGGTTTTTGATTGCGTGTTWATGCTATTMGTAKTGTMTGCCTGGGTG

12e, *Planococcus* sp.:

CCCTTAATACATGCAAGTCGAGCGGAACCAGAGGAGCTTGCTCCTTCTGGTTTAGCGGCGGACGGGTGAGTAACACG
TGGGCAACCTGCCCTGCAGATCGGGATAACTCCGGGAAACCGGTGCTAATACCGAATAGTTTGCGGCCTCTCCTGAG
GCTGCACGGAAAGACGGTCTCGGCTGTCACTGCAGGATGGGCCCGCGGCGCATTAGCTAGTTGGTGGGGTAATGGCC
TACCAAGGCGACGATGCGTAGCCGACCTGAGAGGGTGATCGGCCACACTGGGACTGAGACACGGCCCAGACTCCTA
CGGGAGGCAGCAGTAGGGAATCTTCCGCAATGGACGAAAGTCTGACGGAGCAACGCCGCGTGAGTGACGAAGGTTT
TCGGATCGTAAAACTCTGTTGTGAGGGAAGAACAAGTGCCAACTAACTACTGGCACCTTGACGGTACCTCACCAGAA
AGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGCAAGCGTTGTCCGGAATTATTGGGCGTAAAG
CGCGCGCAGGCGGTTCTTTAAGTCTGATGTGAAAGCCCACGGCTCAACCGTGGAGGGTCATTGGAAACTGGAGAACT
TGAGTACAGAAGWGGAAAGTGGAATTCCATGTGTAGCGGTGAAATGCGTAGAGATGTGGAGGAACACCAGTGGCGA
AGGCGACTTTCTGGTCTGTAACTGACGCTGAGGCGCGAAAGCGTGGAGCAAACAGGATTAGATACCCYGGTAGTCC
ACGCCGYAAACGATGAGTGCTASTGTTTATGGGGTTCYSCCCTTWATAGSTGCASCTAACGCATTAGMCTCCSCTGGG
GAGWACGRCSCAAGCTGAAMTCAAGGAATTGACGRGCCGCCACGAGGACATKGTGATCAGCACGGAGAACTACAGC
TTGAGT

12f, *Planococcus* sp.:

ACCCCAAGTCATCTGTCCCACCTTCGGCGGCTGGCTCCCGTAAGGGTTACCCCACCGACTTCGGGTGTTAAAACTCTC
GTGGTGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGCGGCATGCTGATCCGCGATTACTAGCGATTC
CGGCTTCATGCAGGCGAGTTGCAGCCTGCAATCCGAACTGAGAACGGTTTTCTGGGATTGGCTCCCCCTCGCGGGTTT
GCAGCCCTTTGTACCGTCCATTGTAGCACGTGTGTAGCCCAGGTCATAAGGGGCATGATGATTTGACGTCATCCCCAC
CTTCCTCCGGTTTGTCACCGGCAGTCACCTTAGAGTGCCCAACTGAATGCTGGCAACTAAGATCAAGGGTTGCGCTCG
TTGCGGGACTTAACCCAACATCTCACGACACGAGCTGACGACAACCATGCACCACCTGTCACCGCTGTCCCCGAAGG
GAAAGCCTTGTCTCCAAGGCGGTCAGCGGGATGTCAAGACCTGGTAAGGTTCTTCGCGTTGCTTCGAATTAAACCAC
ATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCCTTTGAGTTTCAGCCTTGCGGCCGTACTCCCCAGGCGGAGTGCT
TAATGCGTTAGCTGCAGCACTAAGGGGCGGAAACCCCCTAACACTTAGCACTCATCGTTTACGGCGTGGACTACCAG
GGTATCTAATCCTGTTTGCTCCCCACGCTTTCGCGCCTCAGCGTCAGTTACAGACCAGAAAGTCGCCTTCGCCACTGG
TGTTCCTCCACATCTCTACGCATTTCACCGCTACACGTGGAATTCCACTTTCCTCTTCTGCACTCAAGTCCCCCAGTTT
CCATGACCCTCCACGATTGAGCCGTGGACTTCACATTCAGACCTAAATGACCGACCTGCCGCGCCGCCTTTTAACGGA
CGCA

12g, *Psychrobacter* sp.:

GATGATAGCTTGCTATCAGGCGTCSMSCGGCGGACGGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAG
CACGGGGAAACTCGTATTAATACCGCATACGACCTACGGGAGAAAGGGGGCAGTTTACTGCTCTCGCTATTAGATGA
GCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATC
AGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGAAAC
CCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCGTG
GTTAATACCCACGGACGATGACATTAGCTGCAGAATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAG
AGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGGGAGCGTAGGTGGCTCTATAAGTCAGATGTGAAATCCCCG
GGCTTTAACCTGGGAACTGCATCTGAAACTGTAGAGCTAGAGTATGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGG
TGAAATGCGTAGAGAWYCTGGAGGAATACCGRATGGCGRAARGCMGSCCTTTYTGGG

12h, *Bacillus* sp.:

AGAGCTTGCTCTTATGAAGTTAGCGGCGGACGGGTGAGTAACACGTGGGTAACCTGCCCATAAGACTGGGATAACTC
CGGGAAACCGGGGCTAATACCGGATAACATTTTGAACCGCATGGTTCGAAATTGAAAGGCGGCTTCGGCTGTCACTT
ATGGATGGACCCGCGTCGCATTAGCTAGTTGGTGAGGTAACGGCTCACCAAGGCAACGATGCGTAGCCGACCTGAGA
GGGTGATCGGCCACACTGGGACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCGCAATG
GACGAAAGTCTGACGGAGCAACGCCGCGTGAGTGATGAAGGCTTTCGGGTCGTAAAACTCTGTTGTTAGGGAAGAAC
AAGTGCTAGTTGAATAAGCTGGCACCTTGACGGTACCTAACCAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCG
GTAATACGTAGGTGGCAAGCGTTATCCGGAATTATTGGGCGTAAAGCGCGCGCAGGTGGTTTCTTAAGTCTGATGTG
AAAGCCCACGGCTCAACCGTGGAGGGTCATTGGAAACTGGGAGACTTGAGTGCAGAAGAGGAAAGTGGAATTCCAT
GTGTAGCGGTGAAATGCGTAGAGATATGGAGGAACMCCAGTGGCGAAAGC

13a, *Shewanella baltica*:
AGGTTAAGCTACCCACTTCTTTTGCAGCCACACCSGKGGKGTGACGGGCGGTGTGTACAAGGCCCGGGAACYTWTTC
ACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACTTCATGGAGTCGAGTTGCAGACTCCAATCCGGACTACGA
CGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAACCCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACT
CGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCTCCGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCACCA
TTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGCGGGACTTAACCCAACATTTCACAACACGAGCTGACGA
CAGCCATGCAKYWYCTGTCTCACGGTTCCCGAAGGCACTAAGCTATCTCTAGCGAATTCCGTGGATGTCAAGAGTAG
GTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCCACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTT
AACCTTGCGGCGTACTCCCCAGGCGGTCTACTTAATGCGTTAGCTTGAGAGCCAGTGTTCAGACACCAAACTCCGAGT
AGACATCGTTTACGCGTGACTACAGGTATCTATCCTGGGTGCTTCCACGCTTCSTGCTGACGTCAGTCTTGTCAGGGG
CGGCTCGCACGGTATTCCTCC

13b, *Shewanella baltica*:
CCGCTCATGACCACAAAGTGGTGAGCGCCCCCCCGAAGGTTAAGCTACCCACTTCTTTTGCAGCCCMYTMMMAWGG
TGTGACGGGCGGTGTGTACAAGGCCCGGGAACGTATTCACCGTGGCATTCTGATCCACGATTACTAGCGATTCCGACT
TCATGGAGTCGAGTTGCAGACTCCAATCCGGACTACGACGAGCTTTGTGAGATTAGCTCCACCTCGCGGCTTTGCAAC
CCTCTGTACTCGCCATTGTAGCACGTGTGTAGCCCTACTCGTAAGGGCCATGATGACTTGACGTCGTCCCCACCTTCCT
CCGGTTTATCACCGGCAGTCTCCCTAGAGTTCCCACCATTACGTGCTGGCAAATAAGGATAGGGGTTGCGCTCGTTGC
GGGACTTAACCCAACATTTCACAACACGAGCTGACGACAGCCATGCAGCACCTGTCTCACAGTTCCCGAAGGCACTA
MKSTATCTCTASYGAATTCYSTGGATGTCAAGAGTAGGTAAGGTTCTTCGCGTTGCATCGAATTAAACCACATGCTCC
ACCGCTTGTGCGGGCCCCCGTCAATTCATTTGAGTTTTAACCTTGCGGCCGTACTCCCCAGGCGGTCTACTTAATGCGT
TAGCTTGAGAGCCCAGTGTTCAAGACACCAAACTCCGAGTAGACATCGTTTACGCGTGAACTACAGTATCTATCTGTT
TGCTCCCACGCTTCGTGCTGAGCGTCAGTCTTTGTCCAGGGGGCCGCCTTCSCCACCGGTATT

13c, *Psychrobacter* sp.:
GACGCCTGGCGGCAGGCTTAACACATGCAAGTCGAGCGGTAACATTTCTAGCTTGCTAGAAGATGACGAGCGGCGGA
CGGGTGAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCACGGGGAAACTCGTATTAATACCGCATACGACC
TACGGGAGAAAGGGGGCAGTTTACTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAG
GCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCC
TACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGGGAAACCCTGATCCAGCCATGCCGCGKGTGTGAAGAAGGC
CTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGA
ATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTA
AAGGGAGCGTAGGTGGCTCTATAAGTCAGATGTGAAATCCCCGGGCTTAACCTGGGAACTGCATCTGAAACTGTAGA
GCTAGAGTATGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGG
CGAAGGCAGCCTTCTGGCATAATACTGACACTGAGGCTCGAAAGCGTGGGTAGCAACAGGATTAGATACCCTGGTAG
TCCACGCCGTAACGATGTCTACTAGTCGTGGGTCCTTGAGGACTTAGTGACSCAGCTAACGCATAAGTAGACSSCTGG
GGGAGTACCGCCCGCAAGGTAWACTCAATGGATTGAYCGGGGTCGCAGCGGTGGRCAGTGGTAATYCATGCACGCG
AGAAACCATACCTG

14a, *Shewanella baltica*:
ATCCCGGGGGCAGCGGGRAGATASTTTGCTATCTTTGCCGGCGAGCGGSGGACGGGTGAGTAATGCCTAGGGATCTG
CCCAGTCGAGGGGGATAACAGTTGGAAACGACTGCTAATACCGCATACSCCCTACGGGGGAAAGGAGGGGACCTTC
GGGCCTTCCGCGATTGGATGAACCTAKGTGGKATTAKCTAKKTGGWGAGGTAATGGCTCACCRRGGMSACKATCCCT
AKSTGYTCTGAGAGGATGATCASCCACWCTGRSACTGASACACGSCCCASACTCCTACGGGAGGCAGCWGKGGRRAA
TATTGCACARTGGGRRAAACCCTGATGCMSCCRTGCCGCGTGTGWGAARAASGCCTTCGGKTTGTAAAGCACTTTCA
RTAGGGAGGAAAGGTAGCAKCTTAATACKCTTKTGCTGTGACKTTMCCTACARAARAAGGACCGGCTAACTCCGTGC
CMGCMSCCGCGGTAATACRGAGGGTCCGAGCGTTAATCRGAWTTACTGGGYGTAAAGCGTGCRCASGCGKTKTGTT
AAGMGAGATGTGAAMGCCCCGSKCTCAACCTGAAWAKTGCATTTCRAACTGGMGAWCTAGASTCTTGTAGAGGGG
GATAGWAYTCCATGTGTAGCGGWGAWATGCGTAGAGATCTGGAGTATACCTGGTGGMGAAGSCGCCC

14b, *Psychrobacter* sp.:
TGGCGGCAGGCTTAACACATGSAAGTCSAGCGGAAACGATGATAGCTTGCTATCAGGCGTCGAGCGGCGGACGGGTG
AGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCACGGGGAAACTCGTATTAATACCGCATACGACCTACGGG
AGAAAGGGGGCAGTTTACTGCTCTCGCTATTAGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTAC
CATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGG
AGGCAGCAGTGGGGAATATTGGACAATGGGGGAAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGG
TTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGAATAAGCA
CCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGGGAG
CGTAGGTGGCTCTATAAGTCAGATGTGAAATCCCCGGGCTTAACCTGGGAACTGCATCTGAAACTGTAGAGCTAGAG
TATGTGAGAGGAAGGTAGAATTCCAGGTGTAGCGGTGAAATGCGTAGAGATCTGGAGGAATACCGATGGCGAAGGC
AGCYTTCTGGCATAATAC

14c, *Psychrobacter cryohalolentis*:
GGAAACGATGATAGCTTGCTATCAGGCGTCGAGAGGCGGACGGGTGAGTAATACTTAGGAATCTACCTAGTAGYYSS
SGWTAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGGGAGAAAGGGGGCAGTTTACTGCTCTCGCTATT
AGATGAGCCTAAGTCGGATTAGCTAGATGGTGGGGTAAAGGCCTACCATGGCGACGATCTGTAGCTGGTCTGAGAGG
ATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGG
GGAAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTGGTTGTAAAGCACTTTAAGCAGTGAAGAAGAC
TCTTCGGTTAATACCCGGWKWCKWTKWCATTAGCTGCAGAATAAGCACCGGCTAACTCTGTGCCAGCAGCCGCGGT
AATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGGGAGCGTAGGTGGCTCGATAAGTCAGATGTGA
AATCCCCCGGGCTCAACCCTGGGAACTGCATCTGATACTGTTGAGCTAGAGTATGTGAGAGGAAGGTAGAAATTYCC
AGGYGTAGCGSTGAAATGCGTAGAGAT

14d, *Arthrobacter arilaitensis*:
TCGAACGATGAAGCCCAGCTTGCTGGGTGGATTAGTGGCGAACGGGTGAGTAACACGTGAGTAACCTGCCCCCGACT
CTGGGATAAGCCCGGGAAACTGGGTCTAATACCGGATATTACCTCTTGCCGCATGGCAGGTGGTGGAAAGATTTATC
GGTGGGGGATGGACTCGCGGCCTATCAGCTTGTTGGTGAGGTAATGGCTCACCAAGGCGACGACGGGTAGCCGGCCT
GAGAGGGTGACCGGCCACACTGGGACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCAC
AATGGGCGAAAGCCTGATGCAGCGACGCCGCGTGAGGGATGACGGCCTTCGGGTTGTAAACCTCTTTCAGTAGGGAA
GAAGCGAAAGTGACGGTACCTGCAGAAGAAGCGCCGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGGCGC
AAGCGTTATCCGGATTTATTGGGCGTAAAGAGCTCGTAGGCGGTTTGTCGCGTCTGCCGTGAAAGTCCGAGGCTCAA
CCTCGGATCTGCGGTGGGTACGGGCAGACTAGAGTGATGTAGGGGAGACTGGAATTCCTGGTGTAGCGGTGAAATGC
GCAGATATCAGGAGGAACACCGATGGCGAAGGCAGGTCTCTGGGCATTTACTGACGCTGAGGAGCGAAAGCATGGG
GAGCGAACAGGATTAGATACCCTGGTAGTCCATGCCGTAACGTTGGGCACTAGGTGTGGGGGACATTCCACGTTTTC
CGCGCCGTAGCTAACGCATTAAGTGCCCCGCCTGGGGGAGTACGGCGCAAGGCTAAACTCAAAGGAATTGRMSGGG
GGGCCSCACAGCGGCGGARCATGSGGATWATTTCGATGCACGCGAGACCTTACCAGCTTGACATGGTGGCAGACCGC
CTYCTCTAGA

15a, *Kocuria* sp.:
GGCGYGCTTAACACATGCAAGYCGAACGCTGAAGCTTGGTGCTTGCACTGGGTGGMTGAGTGGCGAACGGGTGAGT
AATACGTGAGTAACCTGCCCTTGACTCTGGGATAAGCCTGGGAAACTGGGTCTAATACTGGATACGACATGTCACCG
CRTGGTGGTGTGTGGAAAGGGTTTTACTGGTTTTGGATGGKCTCACGGCCTWTCASCTTGTTGGTGGGGTAATGGCTC
ACCARGGCGACGACGGGTAGSCGGCCTGAGAGGGTGACCGGCCACACTGGGACTGAGACACGGCCCAGYCTCCTAC
GGGAGGCAGCAGTGGGGAATATTGCACMATGGGCGAAAGCCTGATGCAGCGACGCCGCGTGAGGGATGACGGCCTT
CGGGTTGTAAACCTCTTTCAGCACGGAAGAAGCGAAAGTGACGGYACGTGCAGAAGAAGCGCCGGCTAACTACGTG
CCAGCAGCCGCGGTAATACGTAGGGCGCAAGCGTTGTCCGGAATTATTGGGCGTAAAGAGCTCGTAGGCGGTTTGTC
GCGTCTGCTGTGAAAGCCCGGGGCTTAACCCCGGGTGTGCAGTGSKTACGGGCAGACTTGAGTGCAGTAGGGGAGAC
TGGAATTCCTGGTGTAGCGGTGAAATGCGCAGATMTCAGGAGGAACACCGATGGCGAAGGCAGGTCTCTGGGCTGTT
ACTGACKCTGRGAGCGAAAGCATGGGGAGCGAACAGGATTAGATACCCTGGTAGWCCATGCCGTAAACGTTGGGCA
CTAGGYGTGGKGAACATTCCAYGTTTTTCCGCGCGTAGCTAACGCATTAMGTGACCCSGCTGGAGAGTACCGGCGCA
GGCTAAACTCRAGTATGACGGGGTCCG

15b, *Kocuria palustris*:
CTGGCGGCGTGCTTAACACATGCAAGTCGAACGCTGAAGCACCAGCTTGCTGGTGTGGATGAGTGGCGAACGGGTGA
GTAATACGTGAGTAACCTGCCCTTGACTCTGGGATAAGCCCGGGAAACTGGGTCTAATACTGGATGCTACATGTCAC
CGCATGGTGGTGTGTGGAAAGGGTTTACTGGTCTTGGATGGGCTCACGGCCTATCAGCTTGTTGGTGAGGTAATGGCT
CACCAAGGCGACGACGGGTAGCCGGCCTGAGAGGGTGACCGGCCACACTGGGACTGAGACACGGCCCASACTCCTA
CGGGAGGCAGCAGTGGGGAATATTGCACAATGGGCGAAAGCCTGATGCAGCGACGCCGCGTGAGGGATGACGGCCT
TCGGGTTGTAAACCTCTTTCAGCAGGGAAGAAGCCACAAGTGACGGTACCTGCAGAAGAAGCGCCGGCTAACTACGT
GCCAGCAGCCGCGGTAATACGTAGGGCGCAAGCGKTGTCCGGAATTATTGGGCGTAAAGAGCTCGTAGGCGGTTTGK
CGCGTCTGCTGTGAAAGCCCGGGGCTTAACCCCGGGTGTGCAGTGSGTACGGGCAGACTMGAGTGCAGTAGGGSAGA
CTGGAATTCCTGGTGTAGCGGWGGAATGCRCAGATATCARGASGAACACCGATGGCGAAGGCAGGTCTCTGGGCTGT
TACTGACGCTGAGGAGCGAMMGCATGGKGAGCGAACAGGATTAGATACCCTGGYAGTCCATGTCGTAAACGTTGGG
CACTASGTGTGGGGGACATTCAYGYTYTCCGCSMCGTAGCTACGCATTASTGCCCTGCTGSTGAGTASGCCGCAGCTG
ACACTCRAGGAATTGACGGGGTTGCACAGCGRCGGAGCATGCCGCATAATTCGA

15c, *Exiquobacterium* sp.:
GACGCTGGCGGCGTGCCTAATACATGCAAGTCGAGCGCAGGAAGCTCRCGGAACTCTTCGGAGGGAAGYGAGTGGA
ATGAGCGGCGGACGGGTGAGTAACACGTAAGGAACCTGCCTCAAGGATTGGGATAACTCCGAGAAATCGGAGCTAA
TACCGGATAGTTCTTCGGACCGCATGGTCCGATGATGAAAGGCGCTYCGGCGTCACCTTGAGATGGCCTTGCGGTGC
ATTAGCTAGTTGGKGGGGTAATGGCCTACCAAGGCGACGATGCATAGCCGACCTGAGAGGGTGATCGGCCACACTGG
GACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTAGGGAATCTTCCACAATGGACGAAAGTCTGATGGAGC
AACGCCGCGTGAGTGATGAAGGTTTTCGGATCGTAAAACTCTGTTGTAAGGGAAGAACAGATACGAGAGGTAATGCT
CGTATCCTGACGGTACCTTGCGAGAAAGCCACGGCTAACTACGTGCCAGCAGCCGCGGTAATACGTAGGTGGCAAGC
GTTGTCCGGAATTATTGGGCGTAAAGCGCGCGCAGGCGGCCTTTTAAGTCTGATGTGAAAGCCCCCGGCTCAACCGG
GGAGGGTCATTGGAAACTGGAAGGCTTGAGTACAGAAGAGAAGAGTGGAATTCCATGTGTAGCGGTGAAATGCGTA
GAGATGTGGAGGAACACCAGTGGCGAAGCGACTCTTTGGTCTGTAACTGACGCTGAGGCGCGAAAGCGTGGGAGCA
AACACGATTAGATACCCTGGTAGTCCACGCGTAACGATGARTGCTASTGTTKKKGGGGTTYTSCCCCTCAWTGCKGA
ARCTMAMGCATWAARMTYCCGCTGGGGAGTACGCCGCAAGCTGAAYTCACACGATGACGGATCGCACGTGGACAK
TGTAATCGAGCAC

15d, Flavobacteriaceae:
GCGGGAGGCCTAACACATGCAAGCCGAGCGGTATTTATTCTTCGGAATAGAGAGAGCGGCGTACGGGTGCGTAACAC
GTGTGCAACCTACCTTTATCAGGAGGATAGCCTTTCGAAAGGAAGATTAATACTCCATAATATATTAGATGGCATCAT
TTAATATTGAAAACTCCGGTGGATAGAGATGGGCACGCGCAAGATTAGATAGTTGGTGAGGTAACGGCTCACCAAGT
CATTGATCTTTAGGGGTCCTGAGAGGGAGATCCCCCACACTGGTACTGAGACACGGACCAGACTCCTACGGGAGGCA
GCAGTGAGGAATATTGGACAATGGGTGAGAGCCTGATCCAGCCATCCCGCGTGAAGGATGACGGTCCTACGGATTGT
AAACTTCTTTTGTATAGGGATAAACCTCTCTACGTGTAGAGAGCTGAAGGTACTATACGAATAAGCACCGGCTAACTC
CGTGCCAGCAGCCGCGGTAATACGGAGGGTGCAAGCGTTATCCGGATTTATTGGGTTTAAAGGGTCCGCAGGCGGGC
CGATAAGTCAGTGGTGAAATCTCATAGCTTAACTATGAAACTGCCATTGATACTGTCGGTCTTGAGTAAATTAGAGGT
AGCTGGAATAAGTARGTGTAGCGGTGAAATGCATAGATATTACTTAGAACACCAATTGCGAAGGCAGGTTACCATGA
TTTAACTGACGCTGAGGGACGAAAGCGTGGGGAGCGAACAGGATTAGATACCCTGGTAGTCCACGCCGTAACGATGC
TAACTCGTTTTGGGGCGCAAGCTTCAGAGACCMAGCGAAGKGATAAGTAGCMCCTGGGGRGTACSWYCGCAGAT

15e, *Psychrobacter faecalis*:
TGGCGGCAGGCTTAACACATGCAAGTCGAGCGGTAACAGGAGAAGCTTGCTTCTCGCTGACGAGCGGCGGACGGGT
GAGTAATACTTAGGAATCTACCTAGTAGTGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGG
GAGAAAGGGGGCAACTTGTTGCTCTCGCTATTARATGAGCCTAAGTCGGATTAGCTAGTTGGTGGGGTAAAGGCCTA
CCAAGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGG
GAGGCAGCAGTGGGGAATATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAAGGCCTTTTG
GTTGTAAAGCACTTTAAGCAGTGAAGAAGACTCCATGGTTAATACCCATGGACGATGACATTAGCTGCAGAATAAGC
ACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATACAGAGGGTGCAAGCGTTAATCGGAATTACTGGGCGTAAAGCGA
GCGTAGGTGGCTTRATAAGTCAGATGTGAAAGCCCCGGGCTTAACCTGGGAACGGCATCTGATACTGTTAGGCTAGA
GTAGGTGAGAGRAAGGTAGAATTCCAGGKGTAGCGGTGAAATGCGTAGAGATYYTGGAGGAAATACCGATGGCGAA
GGCAGCCTTCTGGCATCATACTGACACTGAGGTTCGAAAGCGTGGGTAGCAAACAGGATTAGATACCCTGGTAGTCC
ACGCCGTAACGATGTCTACTAGTCGTGGGTCCCTTGWRGACTTAGTGACGCMGCTATMGCAMTWAAGTAGACMGSC
TGGGGAGWACCRCGCCGCAWGRKTATACATCWCATGAATTGAYSGGGGGCCSCACGTGGACATGKGTAATCSATGC
AGCGCGGAGAAMCATTACCTTGGTCC

15g, *Psychrobacter* sp.:
GGCGGCAGGCTTAACACATGCAAGTCGAGCGGAAACGATGATAGCTTGCTATCAGGCGTCGAGCGGCGGACGGGTG
AGTAATACTTAGGAATCTACCTAGTAGKGGGGGATAGCTCGGGGAAACTCGAATTAATACCGCATACGACCTACGGG
AGAAAGGGGGCARYTTRYTGCTCTCGCTATTARATGAGCCCTAAGTCGGATTAGCTAGATGGTGGGGTATAGGCCTY
CCATGGCGACGATCTGTAGCTGGTCTGAGAGGATGATCAGCCACACCGGGACTGAGACACGGCCCGGACTCCTACGG
GAGGCAGCAGTGGGGATTATTGGACAATGGGGGCAACCCTGATCCAGCCATGCCGCGTGTGTGAAGAKGGCCTTTTG
GTTGTAAWGCACTTTAAGCAGTGAAGAYGACTCCGTGGTTAATACCCATGGACGATGACATTAGCTTGCAGAATAAG
CACCGGCTAACTCTGTGCCAGCAGCCGCGGTAATWCAGAGGGTGCAAGCGTTAATCGGTATTACTGGGCGTAAAGCG
AGCGTAGGTGGCTTGGATAAGTCAGAAGTGAAATCCCCGGGCTTAACCYGGGAACCGCATCTGATACTYGTTWGGCT
WGWRTWGGTGWGTGGAARGGTWGWATTCCAGGTGTAGCGGTGWAATGCGTAGWGATCTGGWGGAATACCGATG
GCGAAGYAKCTTCTTGKCATCATATYGACRCTTGAGATCGAARCGTGGGTAGCAKMAAGATAGATACCCTSTAGTCA
CSCGTAACRATGTCTWCTATCSTTGGTCCTYTGAGAAYATTGACASCTACSATAGTACGCTGAGTACGGCAGTAGCAT
GACACTGCGCGCACCGACTGTAT

15h, *Rothia* sp.:

GTCCGAAAACSGATTGAAGCCCAGCTTGCTGGGCGGATTAGTGGCGAACGGGTGAGTAATACGTGAGTAACCTGCCT
TTAACTCTGGGATAAGCCTTGGAAACGGGGTCTAATACCGGATACGACCAACCCTCGCATGAGGTGTTGGTGGAAAG
GGATTTTGTACTGGTTTTAGATGGGCTCACGGCCTATCAGCTTGTTGGTGAGGTAACGGCTCACCAAGGCGACGACGG
GTAGCCGGCCTGAGAGGGTGACCGGCCACACTGGGACTGAGACACGGCCCAGACTCCTACGGGAGGCAGCAGTGGG
GAATATTGCACAATGGGCGCAAGCCTGATGCAGCGACGCCGCGTGAGGGATGACGGCCTTCGGGTTGTAAACCTCTT
TCAGCAGGGGAGAAGCGAAAGTGACGGTACCTGCAGAAGAAGCGCCGGCTAACTACGTGCCAGCAGCCGCGGTAAT
ACGTAGGGCGCGAGCGTTGTCCGGAATTATTGGGCGTAAAGAGCTTGTAGGCGGTTTGTCGCGTCTGCTGTGAAAGC
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ATTGRCGGGGGGCCSCACAAGCGCGAGCAWKGCGGATWATTCGATGCACGCGGAGAACCTACCAGCCTTGGACATA
TACCTAGACCGCCCTTCAAAGAATGAGGG

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