identified across all assays, highlighting the need for multiple metabarcoding assays to catalogue biodiversity.

4. Berry 2019: using eDNA could see consistent seasonal assemblages of zooplankton species and detect clear departures from the regular seasonal patterns that occurred during an extreme marine heatwave. The integration of eDNA analyses with existing biotic and abiotic surveys delivers a powerful new long-term approach to monitoring the health of our world's oceans

ii. shotgun sequencing

1. sequence parts of whole genome
2. look at frequency of genes giving clue to types of biological processes present
3. identifying species can be hard but possible
4. GOS and TARA Oceans
5. >3um revealed maine diversity 40 million non redundant representative genes used for coding. 81.3% were new

a. Stat 2017:environmental shotgun sequencing (ESS), which randomly sequences fragmented DNA directly from an environmental sample. Furthermore, ESS of genetic material recovered from seawater has mostly been applied to the study of prokaryotes

iii. metagenomic sequencing

. sequence target region like a barcoding gene to identify species present

iv. 16S metabarcoding

1. Temperature of water indicator for community structure
2. >3um mainly bacteria sorted into OTUs increase of richness with depth but decline of overall number

. prokaryotic

3. epipelagic and mesopelagic gene differences

v. 18S rRNA

1. eukaryotic
2. deVargas 2015 how many new taxa with these reads? Metabarcoding nuclear genes encoding 18S rRNA 150,000 OTUs only 11,200 eukaryotic plankton species.
3. Higher OTU diversity in smaller plankton fractions
4. Sequencing of bulk RNA of organisms, for characterisation of genes expressed in the environment

vi. COI metabarcoding

1. Soft benthos

. Guardiola 2015: compare 5 soft benthos communities in the med. communities structured by location and depth, see differences between epifauna and infauna.

2. Hard benthos

. Leray 2015: variation associated with sampling location but lot between size filtrates. Communities differ between size more than site

vii. Metabarcoding eDNA

1. Teleosts: Stoeckle 2017: 2 rivers in NYC collected JUne to JUly. Found 40 species and clear migration or feeding area nature of the estuary. Match results from previous study.
2. Collect water, filter, extract DNA. PCR to allow recognition against database, sequence using illumina MiSeq.
3. Sharks: Boussarie 2018: western pacific islands: baited RUV and eDNA. Took 2785 BRUV samples compared to 22 eDNA: eDNA found 3x more species in wilderness than impacted areas

. Lower field time but more diversity per sample

a. Found elusive species that dont attend BRUV

b. revealed dark diversity to be present like spot tailed shark

4. Stat 2017: PCR amplification of target genes (and taxa) on bulk DNA extracts from the environment can be combined with next-generation sequencing (NGS) to provide high-throughput information on the species

ii. Bilayer fluidity is important property that has undergone adaptive regulation in deep sea species because of strong effect of pressure but combined with low temperature of water as both increase viscosity and reduce membrane fluidity

1. to maintain correct fluidity of membranes level of saturation of lipids is controlled with lower temperature meaning more unsaturated components and increase saturation in tails
2. Cossins 1989

. ratio of unsaturated fatty acids decreases with depth

a. Homeoviscous adaptation: correlation between the depth fish live at and the ratio of saturated to unsaturated fatty acids, saturation ratio goes down.

b. BUT paper didnt look at context of history and how related animals are used. So when look at relationships between properties and animals across phylogenetic tree need to check how related they are and the evolutionary history

c. Once taken into account and corrected for (Phylogenetically correlated Lees squares analysis) is negative correlation between depth and how compressible proteins are

3. Rhodopsin: as deeper find specific amino acid sites selected for to decrease how much compress
4. Animals adapted to high pressure are often obligate barophilic

iii. Hydrothermal vents

1. ALVIN found hydrothermal vents: lot of range in temperature
2. Organisms are chemoautotrophic: use energy from chemical reactions to make sugars but can make in different ways

. some are methanogens: reduce CO_2 into methane and anaerobically reduce HS and CO_2 into biomass and H_2O

3. Green sulphur bacteria: anaerobes that need light for growth by oxidation of sulphur compound to reduce CO_2 to organic carbon and are capable of photosynthetic growth at low light levels as exist at 1000m
4. Find tube worms, clams, mussels, first vents in Galapagos rift dominated by tube worms

. Mid atlantic ridge vents

a. Tag mount: have lot of shrimp and extensive anemone beds

b. Not same composition in communities. The ecological characteristics seem different from pacific vents

. Pacific: bulk of chemoautotrophic microbes are sulphur oxidising. These were endosymbionts in tissues of animals and transferred sugars and carbon to animals

i. Atlantic: free swimming or epibiotic microbes

c. But differences in ecological composition:

. O_2/iron/sulphur levels correlate with distribution of specific taxa in microhabitats

i. Higher temperature: formation of soluble iron sulphide reduces availability of Hydrogen sulphide to vent organisms: controlling habitat - less methanogens

1. Even though can be sulphur driven in methane producing microbes, actual chemical structure around them is what caused different species to evolve.

d. Driver of speciation

. Chemical speciation of elements controls biological community because interplay of O_2, HS, Fe_2 governs ecology. Have high levels of elemental materials in deep sea but where other places in world where plates spreading release different chemicals but might not get superheated water

1. Castello Aragonese: CO_2 vents. As get closer to higher CO_2 concentrations, get biodiversity loss because of pH drop as the water absorbs the CO_2 so ⅓ of species crashed.
2. Expect the same drop in species over next 100 years due to ocean acidification
3. Sea grass and brown algae thrive along natural pH gradient where aragonitic and then get

1. outweighed any other environmental variable like chlorophyll production. fish biomass greatest with more staff
2. good as this can be fixed with financial investment
3. But most are understaffed globally so need investment

iv.The future of MPAs

1. encourage investment by government by emphasising the good things the marine environment does

. raise awareness of importance of seas for many goods services

a. realise importance of seas for society- more willing there will be to engage in change

2. But most need to be pressed by government and media to act so need to have appropriate evidence

. UK: science evidence changed policies like enhancing recycling and restricting access to plastic bags

a. scientific influence on policy shouldn't be underrated

e. Ocean Optimism

.protecting spaces

i.saving species

ii.cleaning up pollution

iii.help from science and technology

1. need to be positive and need good stories from success of MPAs in enabling marine habitats and their species to recover
2. getting better at protecting spaces and saving species
3. science helping to identify the issues and push policy makers to act

Thiault 2019: Island of moorea: Fully protected areas provided greater ecological benefits than moderately protected areas. Small response to protection due to weak surveillance and compliance but also! Crown of thorns outbreak and cyclone disrupted the ability to provide benefits. Shows the importance of using fully protected MPAs over moderately protected MPAs to achieve conservation objectives, even in complex social–ecological settings, but also stress the need to monitor effects and adapt management based on ongoing assessments.