Probing the relationship between fluid mixing, biodiversity, and productivity in Yellowstone hot springs

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1
00:00:05,269 --> 00:00:03,270
hello my name is maria and i'm a second

2
00:00:07,430 --> 00:00:05,279
year phd student at montana state

3
00:00:08,549 --> 00:00:07,440
university at dr boyle lab

4
00:00:10,390 --> 00:00:08,559
and i'm going to be talking about

5
00:00:12,709 --> 00:00:10,400
probing the relationship between food

6
00:00:14,629 --> 00:00:12,719
mixing biodiversity and productivity in

7
00:00:16,390 --> 00:00:14,639
yellowstone hot springs

8
00:00:18,950 --> 00:00:16,400
to talk about that we need to first

9
00:00:21,429 --> 00:00:18,960
visit early earth and early live

10
00:00:23,349 --> 00:00:21,439
metabolic pathways so i know that all

11
00:00:23,910 --> 00:00:23,359
this evidence for life and lands in a

12
00:00:27,189 --> 00:00:23,920
hydrogen

13
00:00:28,950 --> 00:00:27,199

environment dating back to 3.5 years ago

14
00:00:31,109 --> 00:00:28,960
over here i'm bringing a timeline of

15
00:00:33,110 --> 00:00:31,119
earth history with for

16
00:00:34,470 --> 00:00:33,120
with the time in billions of years on

17
00:00:37,110 --> 00:00:34,480
the y-axis

18
00:00:38,470 --> 00:00:37,120
and then oxygen concentrations on the

19
00:00:40,790 --> 00:00:38,480
x-axis here

20
00:00:43,030 --> 00:00:40,800
and i've highlighted the period of the

21
00:00:44,630 --> 00:00:43,040
time of only earth that we think

22
00:00:46,790 --> 00:00:44,640
increased volcanic activity was

23
00:00:49,350 --> 00:00:46,800
happening and that is important because

24
00:00:50,069 --> 00:00:49,360
volcanoes are speeding chemical forms of

25
00:00:51,590 --> 00:00:50,079
energy

26
00:00:53,270 --> 00:00:51,600
that microbes can use for their

27
00:00:56,950 --> 00:00:53,280
metabolic pathways

28
00:00:57,590 --> 00:00:56,960
so i know that on early earth this life

29
00:01:00,150 --> 00:00:57,600
was

30
00:01:01,510 --> 00:01:00,160
very likely based on chemosynthesis and

31
00:01:03,510 --> 00:01:01,520
that's also

32
00:01:05,830 --> 00:01:03,520
true for the primary production since

33
00:01:06,789 --> 00:01:05,840
that was the uh the likely pathway

34
00:01:08,710 --> 00:01:06,799
happening

35
00:01:09,990 --> 00:01:08,720
so we know that uh since the beginning

36
00:01:12,870 --> 00:01:10,000
of our history

37
00:01:14,469 --> 00:01:12,880
life was chemosynthetic and of course

38
00:01:17,109 --> 00:01:14,479

that changed when life

39
00:01:19,190 --> 00:01:17,119
figure out how to use sunlight to then

40
00:01:21,749 --> 00:01:19,200
be able to do photosynthesis

41
00:01:23,190 --> 00:01:21,759
and that changed our surface and

42
00:01:25,190 --> 00:01:23,200
atmosphere a lot

43
00:01:27,030 --> 00:01:25,200
however what i really want to point out

44
00:01:28,710 --> 00:01:27,040
here is that chemosynthesis was

45
00:01:31,749 --> 00:01:28,720
happening since the beginning

46
00:01:35,030 --> 00:01:31,759
and is still happening until this day so

47
00:01:39,030 --> 00:01:35,040
of course photosynthesis has taken over

48
00:01:41,990 --> 00:01:39,040
a lot of this primary production

49
00:01:44,630 --> 00:01:42,000
responsibility however we can still find

50
00:01:47,429 --> 00:01:44,640
environments to study chemosynthetic

51
00:01:48,469 --> 00:01:47,439
primary productivity that is not only on

52
00:01:51,270 --> 00:01:48,479
the deep sea

53
00:01:51,910 --> 00:01:51,280
or on dark environments so we kind of

54
00:01:53,910 --> 00:01:51,920
have can

55
00:01:56,149 --> 00:01:53,920
travel back in time when we visit hot

56
00:01:58,149 --> 00:01:56,159
springs modern hot springs can be seen

57
00:02:00,789 --> 00:01:58,159
as this model that allows us for

58
00:02:01,830 --> 00:02:00,799
investigating this chemosynthetic base

59
00:02:04,230 --> 00:02:01,840
productivity

60
00:02:07,270 --> 00:02:04,240
in the absence of photosynthesis because

61
00:02:10,309 --> 00:02:07,280
in hot springs we have a

62
00:02:12,790 --> 00:02:10,319
inhibition of photosynthesis based on ph

63
00:02:14,550 --> 00:02:12,800

we can see here on the y-axis on the end

64
00:02:17,430 --> 00:02:14,560
temperature we can see here on the

65
00:02:18,150 --> 00:02:17,440
on the x-axis so on the with the white

66
00:02:24,630 --> 00:02:18,160
square

67
00:02:26,869 --> 00:02:24,640
genes are absent which means that this

68
00:02:28,710 --> 00:02:26,879
primary productivity

69
00:02:29,990 --> 00:02:28,720
in this environment here is based on

70
00:02:32,390 --> 00:02:30,000
chemosynthesis

71
00:02:34,390 --> 00:02:32,400
so when we go to a hot spring we can cut

72
00:02:36,790 --> 00:02:34,400
we can kind of travel back in time

73
00:02:38,470 --> 00:02:36,800
as we increase in temperature and

74
00:02:42,070 --> 00:02:38,480
decreasing ph

75
00:02:45,030 --> 00:02:42,080
uh so we know that for example in some

76
00:02:46,710 --> 00:02:45,040
really hot hot spring spools this

77
00:02:47,990 --> 00:02:46,720
primary productivity is based on

78
00:02:50,309 --> 00:02:48,000
chemosynthesis

79
00:02:52,390 --> 00:02:50,319
so why is that important well in macro

80
00:02:54,229 --> 00:02:52,400
ecology biodiversity and productivity

81
00:02:55,030 --> 00:02:54,239
relationships has been extensively

82
00:02:58,229 --> 00:02:55,040
studied

83
00:02:59,830 --> 00:02:58,239
so we see that for example when three

84
00:03:01,110 --> 00:02:59,840
species regions increase the

85
00:03:02,830 --> 00:03:01,120
productivity

86
00:03:04,630 --> 00:03:02,840
also increases in a positive

87
00:03:08,149 --> 00:03:04,640
relationship

88
00:03:09,990 --> 00:03:08,159

in microbial ecology however all of this

89
00:03:11,670 --> 00:03:10,000
relationship has been probed in

90
00:03:13,990 --> 00:03:11,680
environments that are based on

91
00:03:16,949 --> 00:03:14,000
photosynthesis as well

92
00:03:18,869 --> 00:03:16,959
just like macroecology so we see some

93
00:03:21,110 --> 00:03:18,879
different types of relationships they're

94
00:03:22,949 --> 00:03:21,120
not always positive relationships we

95
00:03:24,949 --> 00:03:22,959
have other types of relationships that

96
00:03:27,750 --> 00:03:24,959
happen between biodiversity

97
00:03:28,710 --> 00:03:27,760
and productivity here those measurements

98
00:03:32,470 --> 00:03:28,720
are

99
00:03:35,430 --> 00:03:32,480
generally based on this in

100
00:03:36,710 --> 00:03:35,440
indirect measure or chlorophyll um and

101
00:03:38,949 --> 00:03:36,720
we can then see

102
00:03:40,869 --> 00:03:38,959
that we have different relationships

103
00:03:42,470 --> 00:03:40,879
however there is a lack of research on

104
00:03:43,509 --> 00:03:42,480
biodiversity and productivity

105
00:03:47,750 --> 00:03:43,519
relationship

106
00:03:50,630 --> 00:03:47,760
that is solely based on chemosynthesis

107
00:03:52,309 --> 00:03:50,640
so because of that we might think well

108
00:03:54,789 --> 00:03:52,319
how can we approach that question

109
00:03:56,630 --> 00:03:54,799
and what can help promote biodiversity

110
00:03:59,750 --> 00:03:56,640
for chemosynthetic

111
00:04:01,350 --> 00:03:59,760
environments so we know uh and we

112
00:04:04,070 --> 00:04:01,360
hypothesized that

113
00:04:05,990 --> 00:04:04,080

for chemosynthesis since they are based

114
00:04:07,190 --> 00:04:06,000
on the availability of nutrients or

115
00:04:08,789 --> 00:04:07,200
different chemical

116
00:04:10,949 --> 00:04:08,799
energy sources present on the

117
00:04:12,869 --> 00:04:10,959
environment we might hypothesize them

118
00:04:15,110 --> 00:04:12,879
more redux pairs

119
00:04:16,469 --> 00:04:15,120
which means more nutrients will mean

120
00:04:18,150 --> 00:04:16,479
more niche space

121
00:04:21,830 --> 00:04:18,160
which might support a higher

122
00:04:24,070 --> 00:04:21,840
biodiversity so a quick way to see this

123
00:04:25,350 --> 00:04:24,080
in bringing already that you have hot

124
00:04:27,510 --> 00:04:25,360
springs here

125
00:04:29,030 --> 00:04:27,520
is that for example when a hot spring

126
00:04:31,830 --> 00:04:29,040
one where we have

127
00:04:33,670 --> 00:04:31,840
three different uh redox pairs and is a

128
00:04:35,670 --> 00:04:33,680
reduced environment where there is no

129
00:04:37,670 --> 00:04:35,680
oxygen present if we have three

130
00:04:40,469 --> 00:04:37,680
different niche spaces here

131
00:04:42,390 --> 00:04:40,479
we might support three different species

132
00:04:45,990 --> 00:04:42,400
in a very simple way to

133
00:04:48,150 --> 00:04:46,000
show this in opposite idea if we have an

134
00:04:50,070 --> 00:04:48,160
oxidized spring where we can have two

135
00:04:52,870 --> 00:04:50,080
different niche spaces here

136
00:04:53,510 --> 00:04:52,880
we might support two species however if

137
00:04:55,350 --> 00:04:53,520
you mix

138
00:04:57,270 --> 00:04:55,360

these two environments so if you have a

139
00:05:00,790 --> 00:04:57,280
hot spring that is mixed

140
00:05:02,710 --> 00:05:00,800
we will have a higher range of niche

141
00:05:05,029 --> 00:05:02,720
spaces which might support

142
00:05:06,550 --> 00:05:05,039
more species which will mean that that's

143
00:05:10,070 --> 00:05:06,560
increased biodiversity

144
00:05:12,469 --> 00:05:10,080
which might promote primary production

145
00:05:14,230 --> 00:05:12,479
so i hypothesize that in yellowstone

146
00:05:16,230 --> 00:05:14,240
national park hot springs

147
00:05:17,430 --> 00:05:16,240
the increased fluid mixing sourcing

148
00:05:19,590 --> 00:05:17,440
those waters

149
00:05:22,230 --> 00:05:19,600
might increase the availability of

150
00:05:23,990 --> 00:05:22,240
nutrients which means more redox pairs

151
00:05:26,310 --> 00:05:24,000
that will increase them from

152
00:05:28,629 --> 00:05:26,320
biodiversity and that would then

153
00:05:31,430 --> 00:05:28,639
increase primary productivity

154
00:05:33,749 --> 00:05:31,440
so yellowstone national park hosts the

155
00:05:36,230 --> 00:05:33,759
largest hydrothermal system on earth

156
00:05:37,990 --> 00:05:36,240
is also very close to us here in montana

157
00:05:40,469 --> 00:05:38,000
which makes it very suitable

158
00:05:42,150 --> 00:05:40,479
uh environment to research on it has

159
00:05:44,070 --> 00:05:42,160
more than ten thousand pure thermal

160
00:05:45,029 --> 00:05:44,080
features and they have a wide range of

161
00:05:47,749 --> 00:05:45,039
your chemistry

162
00:05:49,029 --> 00:05:47,759
which allow us to uh really understand

163
00:05:52,710 --> 00:05:49,039

how this environment

164
00:05:55,350 --> 00:05:52,720
might be uh promoting biodiversity

165
00:05:57,990 --> 00:05:55,360
so yellowstone natural park has a really

166
00:06:00,550 --> 00:05:58,000
interesting way of the ph distribution

167
00:06:02,469 --> 00:06:00,560
it is a bi-molded distribution uh that

168
00:06:03,990 --> 00:06:02,479
is based on the subsurface processes

169
00:06:05,110 --> 00:06:04,000
happening there that i'm not gonna have

170
00:06:07,430 --> 00:06:05,120
time to explain

171
00:06:09,270 --> 00:06:07,440
but what's important here to see is that

172
00:06:12,390 --> 00:06:09,280
uh hot springs in yellowstone have

173
00:06:14,790 --> 00:06:12,400
this bimodal ph of acidic of less

174
00:06:16,070 --> 00:06:14,800
ph less than four and we have high

175
00:06:18,790 --> 00:06:16,080
sulfate and low

176
00:06:20,390 --> 00:06:18,800
chloride which is on those hot springs

177
00:06:21,830 --> 00:06:20,400
and we also have more neutral to

178
00:06:25,830 --> 00:06:21,840
alkaline hot springs

179
00:06:28,870 --> 00:06:25,840
uh higher than six which have more

180
00:06:29,350 --> 00:06:28,880
uh more chloride than sulfate so we can

181
00:06:31,749 --> 00:06:29,360
use

182
00:06:33,350 --> 00:06:31,759
sulfite and chloride ratios to aid in

183
00:06:36,309 --> 00:06:33,360
understanding the water sourcing your

184
00:06:37,909 --> 00:06:36,319
fluid mixing patterns of hot springs

185
00:06:41,029 --> 00:06:37,919
another way to visualize this is

186
00:06:43,350 --> 00:06:41,039
spotting that in a in a

187
00:06:45,830 --> 00:06:43,360
sulfate chloride ratio so you can see

188
00:06:47,350 --> 00:06:45,840

here that low sulfate low chloride means

189
00:06:50,230 --> 00:06:47,360
that these waters come

190
00:06:53,189 --> 00:06:50,240
from rainfall and snow melt and then we

191
00:06:55,589 --> 00:06:53,199
see when you have high chloride

192
00:06:57,029 --> 00:06:55,599
and kind of medium sulfate here those

193
00:07:00,550 --> 00:06:57,039
come from the aquifer

194
00:07:02,790 --> 00:07:00,560
some the deep hydrothermal aquifer

195
00:07:04,230 --> 00:07:02,800
of yellowstone and of course you can

196
00:07:06,469 --> 00:07:04,240
have gas input there

197
00:07:08,390 --> 00:07:06,479
which is going to increase the sulfate

198
00:07:08,950 --> 00:07:08,400
and then we also have a lot of mixing

199
00:07:12,309 --> 00:07:08,960
happen

200
00:07:13,909 --> 00:07:12,319
in um in between all of these n members

201
00:07:16,230 --> 00:07:13,919
over here

202
00:07:17,670 --> 00:07:16,240
so we see that mixing is quite important

203
00:07:21,110 --> 00:07:17,680
now some hot springs

204
00:07:22,390 --> 00:07:21,120
and so i went to then um pursue my

205
00:07:24,870 --> 00:07:22,400
objectives with this

206
00:07:26,870 --> 00:07:24,880
hypothesis which was characterizing the

207
00:07:27,830 --> 00:07:26,880
fluid mixing regime of selected hot

208
00:07:29,350 --> 00:07:27,840
springs

209
00:07:30,950 --> 00:07:29,360
and characterizing the microbial

210
00:07:33,029 --> 00:07:30,960
community biodiversity

211
00:07:34,469 --> 00:07:33,039
and quantifying the microbial community

212
00:07:35,909 --> 00:07:34,479
primary productivity

213
00:07:37,830 --> 00:07:35,919

i'm not going to have time to give you

214
00:07:40,870 --> 00:07:37,840
the methods but

215
00:07:44,070 --> 00:07:40,880
we can have questions being answered

216
00:07:44,790 --> 00:07:44,080
by email later on so we chose hot

217
00:07:48,550 --> 00:07:44,800
springs

218
00:07:50,950 --> 00:07:48,560
um that is called the roadside and this

219
00:07:52,309 --> 00:07:50,960
is a model system already characterized

220
00:07:54,070 --> 00:07:52,319
by lindsay at all

221
00:07:55,990 --> 00:07:54,080
in their model system because they have

222
00:07:57,990 --> 00:07:56,000
these two by this bi-mode of

223
00:08:00,710 --> 00:07:58,000
distribution of hot springs

224
00:08:01,670 --> 00:08:00,720
with roadside west being a hydrothermal

225
00:08:05,029 --> 00:08:01,680
only with ph

226
00:08:07,189 --> 00:08:05,039
more than six temperatures around 70.

227
00:08:08,070 --> 00:08:07,199
we have roadside east which is acidic

228
00:08:11,029 --> 00:08:08,080
hot spring

229
00:08:12,790 --> 00:08:11,039
with increased temperature however we

230
00:08:14,469 --> 00:08:12,800
have this third hot spring that hasn't

231
00:08:17,589 --> 00:08:14,479
been fully characterized

232
00:08:17,990 --> 00:08:17,599
and his name is rosa nor you will see

233
00:08:20,550 --> 00:08:18,000
that

234
00:08:22,390 --> 00:08:20,560
the temperatures is also very hot but

235
00:08:24,950 --> 00:08:22,400
the ph is at 5.1

236
00:08:26,629 --> 00:08:24,960
which falls outside of our bimodal

237
00:08:28,390 --> 00:08:26,639
distribution so i just put an

238
00:08:28,950 --> 00:08:28,400

interrogation point there because we

239
00:08:32,070 --> 00:08:28,960
don't

240
00:08:33,190 --> 00:08:32,080
fully know how is um being influenced by

241
00:08:35,670 --> 00:08:33,200
the which type of

242
00:08:37,430 --> 00:08:35,680
mixing regime so that was my first

243
00:08:39,269 --> 00:08:37,440
objective and i'm just going to bring

244
00:08:40,389 --> 00:08:39,279
you here that plot of sulfate and

245
00:08:42,230 --> 00:08:40,399
chloride again

246
00:08:45,190 --> 00:08:42,240
and plot my hot springs in here so we

247
00:08:47,430 --> 00:08:45,200
can understand the water sourcing

248
00:08:49,590 --> 00:08:47,440
so we see that roadside west on the

249
00:08:51,509 --> 00:08:49,600
triangle here indeed is a hydrothermal

250
00:08:55,030 --> 00:08:51,519
only water sourcing

251
00:08:55,350 --> 00:08:55,040
high chloride low sulfate ratios rosette

252
00:08:58,870 --> 00:08:55,360
is

253
00:09:01,190 --> 00:08:58,880
spring

254
00:09:02,310 --> 00:09:01,200
with low with high sulfate and low

255
00:09:04,389 --> 00:09:02,320
chloride

256
00:09:06,550 --> 00:09:04,399
and then with zero cyanide actually

257
00:09:08,230 --> 00:09:06,560
falls really close to rho side ease

258
00:09:10,790 --> 00:09:08,240
which doesn't fully make sense since the

259
00:09:13,110 --> 00:09:10,800
ph is quite different at 5.1

260
00:09:15,350 --> 00:09:13,120
so when we look at the gas um dissolved

261
00:09:16,949 --> 00:09:15,360
gas quantification in these hot springs

262
00:09:19,269 --> 00:09:16,959
we then start to understand a little bit

263
00:09:22,310 --> 00:09:19,279

more so on the y-axis we have

264
00:09:24,150 --> 00:09:22,320
methane hydrogen and co2

265
00:09:25,829 --> 00:09:24,160
and on the y-axis we have our hot

266
00:09:27,430 --> 00:09:25,839
springs we see the roadside west and

267
00:09:29,670 --> 00:09:27,440
roadside east

268
00:09:31,190 --> 00:09:29,680
they have you know this low range of gas

269
00:09:33,269 --> 00:09:31,200
which is normal

270
00:09:35,509 --> 00:09:33,279
but most of the springs in yellowstone

271
00:09:37,990 --> 00:09:35,519
but when we see roadside north that is

272
00:09:38,870 --> 00:09:38,000
very striking that rosy north receives a

273
00:09:41,670 --> 00:09:38,880
lot of gas

274
00:09:43,269 --> 00:09:41,680
so we call this hot spring meteoric

275
00:09:47,110 --> 00:09:43,279
meteorite plus gas

276
00:09:47,509 --> 00:09:47,120
plus more gas being input in this hot

277
00:09:50,150 --> 00:09:47,519
spring

278
00:09:51,910 --> 00:09:50,160
so a lot of gas and that makes sense

279
00:09:53,670 --> 00:09:51,920
when we visit our map again and i'll

280
00:09:56,870 --> 00:09:53,680
show you that there is a trimmer roll

281
00:09:58,230 --> 00:09:56,880
right across roadside north so that

282
00:10:01,350 --> 00:09:58,240
means that rosanna

283
00:10:03,750 --> 00:10:01,360
is in this line of this gas input and

284
00:10:05,590 --> 00:10:03,760
then this ph is likely being buffered by

285
00:10:08,710 --> 00:10:05,600
the co2 bicarbonate

286
00:10:11,350 --> 00:10:08,720
system and then we can then

287
00:10:12,949 --> 00:10:11,360
conclude that rho cyanide is the result

288
00:10:14,949 --> 00:10:12,959

of extensive food mixing

289
00:10:15,990 --> 00:10:14,959
when in comparison to the other two hot

290
00:10:18,470 --> 00:10:16,000
springs

291
00:10:19,750 --> 00:10:18,480
so how does that affect the biodiversity

292
00:10:21,590 --> 00:10:19,760
we can see here that

293
00:10:22,790 --> 00:10:21,600
our meta genome assembled genomes

294
00:10:24,949 --> 00:10:22,800
relative abundance

295
00:10:27,190 --> 00:10:24,959
really show a difference as well so when

296
00:10:28,550 --> 00:10:27,200
we see world sideways on planktonic and

297
00:10:31,590 --> 00:10:28,560
sediment communities

298
00:10:34,470 --> 00:10:31,600
we have um only a few

299
00:10:35,430 --> 00:10:34,480
species here um with one species being

300
00:10:37,670 --> 00:10:35,440
more dominant

301
00:10:39,030 --> 00:10:37,680
and those are all bacteria when we look

302
00:10:41,670 --> 00:10:39,040
around side east

303
00:10:43,590 --> 00:10:41,680
uh we could only have dna for the

304
00:10:46,150 --> 00:10:43,600
planktonic community and not settlement

305
00:10:48,389 --> 00:10:46,160
but we see the same trend where one one

306
00:10:50,069 --> 00:10:48,399
species is more dominant

307
00:10:52,710 --> 00:10:50,079
and then when we see and then it's

308
00:10:55,030 --> 00:10:52,720
archaea based when we several side nor

309
00:10:57,190 --> 00:10:55,040
both planktonic and sediment communities

310
00:10:59,110 --> 00:10:57,200
uh more evenly distributed

311
00:11:00,710 --> 00:10:59,120
uh bonuses and they have a mix of

312
00:11:03,670 --> 00:11:00,720
bacteria and archaea

313
00:11:04,389 --> 00:11:03,680

so that means that when we look at more

314
00:11:07,430 --> 00:11:04,399
in detail

315
00:11:08,710 --> 00:11:07,440
a statistic analysis of diversity such

316
00:11:12,829 --> 00:11:08,720
as symptom index

317
00:11:15,110 --> 00:11:12,839
we see that roadside north has more

318
00:11:17,269 --> 00:11:15,120
biodiversity

319
00:11:18,870 --> 00:11:17,279
when we look at the genomic diversity we

320
00:11:21,350 --> 00:11:18,880
did the

321
00:11:23,590 --> 00:11:21,360
analysis called non-parallel diversity

322
00:11:26,949 --> 00:11:23,600
and we see the rural side north

323
00:11:29,110 --> 00:11:26,959
it is again more diverse so

324
00:11:31,509 --> 00:11:29,120
uh we see here that this is a whole

325
00:11:34,790 --> 00:11:31,519
metagenomic analysis so not just

326
00:11:36,710 --> 00:11:34,800
the genomes that will assemble into max

327
00:11:38,550 --> 00:11:36,720
and this gives you a full picture of the

328
00:11:41,190 --> 00:11:38,560
meta genome and show us that

329
00:11:42,069 --> 00:11:41,200
a rosanna is more diverse when we then

330
00:11:45,110 --> 00:11:42,079
see the primary

331
00:11:48,550 --> 00:11:45,120
productivity uh using 14c

332
00:11:50,870 --> 00:11:48,560
bicarbonate label assays

333
00:11:52,389 --> 00:11:50,880
we also see the same thing so primary

334
00:11:55,269 --> 00:11:52,399
productivity is higher

335
00:11:57,430 --> 00:11:55,279
in rose side north than rose side west

336
00:11:59,110 --> 00:11:57,440
and east for both planktonic and

337
00:12:01,750 --> 00:11:59,120
sediment communities

338
00:12:02,470 --> 00:12:01,760

so in conclusion i saw that rural sainor

339
00:12:05,670 --> 00:12:02,480
is more

340
00:12:09,269 --> 00:12:05,680
has more fluid mixing it is also

341
00:12:12,230 --> 00:12:09,279
more taxonomic and more genomic diverse

342
00:12:14,069 --> 00:12:12,240
and that means and that the primary

343
00:12:17,030 --> 00:12:14,079
productivity there is also

344
00:12:17,829 --> 00:12:17,040
higher than the other two hot springs

345
00:12:19,670 --> 00:12:17,839
here are some

346
00:12:21,670 --> 00:12:19,680
future work but i need to finalize

347
00:12:23,829 --> 00:12:21,680
functional diversity analysis

348
00:12:24,949 --> 00:12:23,839
and maybe test my hypothesis in a larger

349
00:12:27,110 --> 00:12:24,959
sample size

350
00:12:29,190 --> 00:12:27,120
while holding the temperature constant

351
00:12:31,030 --> 00:12:29,200
since that could have some influence